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SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXVIII] NUMBER 2022 NEW YORK, OCTOBER 3, 1914 [10 CENTS A COPY $5.00 A YEAR

Nocturnal Warfare

The Automobile-Mounted Searchlights of the French Army

We are accustomed in these days to find the automobile put to a variety of practical uses. One of the recent developments of this kind is a traveling searchlight carried upon an automobile, and designed for military use in the French army. The general aspect of this new piece of military equipment is shown in Fig. 1 of our illustrations. The second figure shows some of the detail features of the arrangement for loading and unloading the truck for carrying the searchlight. The car can be propelled at some 19 miles an hour by an 18 horse-power motor burning gasoline, alcohol or oil, and capable of negotiating a 12 to 15 per cent grade. The fuel consumption is given as a little over 10 gallons per 100 miles. Both the automobile motor and that of the generator are of the De Dion Bouton type. The searchlight is a 7,000 candle-power electric arc lamp fitted with a 38-inch reflector. It is mounted upon a truck and can be taken from the car and set up at any suitable point within a distance of 328 feet, this being the length of the flexible current leads from the lamp to the car. The searchlight may, of course, be operated in its position on the car, if desired, but as a rule it is preferable to effect its manipulation from a distance, so as to avoid looking along the beam, and thus having a deep layer of brightly illuminated haze interposed between the eye and the object sighted, clouding the latter from view. In time of war it may also be an advantage to be able to place the searchlight in a comparatively exposed position, and yet to operate it from under cover. The device employed for this manipulation from a distance is very ingenious; without going into a full description it may here be said that its operation is based on the response of a tuning fork at the searchlight to a vibrating current sent out from a contact breaker tuned in unison with the tuning fork. There are as many tuning forks as there are different movements, each tuning fork responding to a specific contact breaker.

For field work, glass reflectors are undesirable owing

Fig. 1.—Automobile-mounted searchlight in use by the French army.

Fig. 2.—View showing loading and unloading facilities.

THE SEARCHLIGHT IN WAR

to their fragility. Silvered metal mirrors are unsatisfactory owing to the fact that they become tarnished under the influence of the electric arc. Of late, gilded mirrors have been used with success. The brightness of the electric arc may reach a figure as high as 250 candle-power per square millimeter. By the way of comparison it may be mentioned that lime light gives at most only 8 candle-power for the same area. The light comes almost entirely from the positive carbon, and the two electrodes are placed accordingly, so as to give the best effect. With a reflector of 60 inches diameter, good observations can be made at a distance of from two to three miles.

Train Signaling in France

In France, automatic train signaling has been adopted, or is being tested, on most of the principal lines, notably the Northern, Eastern, and Southern Railways, the Paris, Lyons and Mediterranean Railway, and the Orléans and State Railways.

Full descriptions of the various types of signaling apparatus adopted on each of the above lines were given a few days ago at the Paris meeting of the Institution of Mechanical Engineers by the engineers on the several lines. Most of the systems adopted are on the ramp principle, a metallic brush depending from the engine making electrical contact with a ramp placed between the rails and connected with the signal at the side of the line, thus giving a visible, and usually audible, warning in the driver's cab if the signal be at danger.

A typical warning and recording apparatus for signals at danger which is now adopted by the Paris, Lyons and Mediterranean Company on 140 express locomotives and on 258 miles of double track, with 316 signals fully equipped, was well described by Mr. L. Maréchal of the Paris, Lyons and Mediterranean Railway. Not only does the apparatus actuate a special whistle which warns the driver and stoker, but it gives on a speed-indicator roll a sign indicating which signal it was that stood at danger. The apparatus placed on the track comprises an insulated conductor, called a "crocodile" or ramp, placed as above described, and a switch worked by the signal and connected to the ramp and to the rails.

The apparatus on the engine consists of a brush which rubs on the ramp when the engine passes over it; a pneumatic horn giving the warning; an automatic device for unclutching and sending compressed air through the horn; an automatic device acting on the registering mechanism of the speed indicator; an electro-pneumatic relay, which provides the unclutching device at the horn and the registering apparatus with the compressed air required; a battery which provides the current for the electro-pneumatic relay; and, lastly, a compressed air receiver which feeds the apparatus.

This warning and registering system is thus based on the combined use of electricity and compressed air. It makes it necessary to use switches and ramps similar to those adopted on other railways where the system is entirely electrical. In this latter case electricity is the medium which brings about the unclutching of the apparatus during the very short time that the engine takes to pass over a ramp. This unclutching means a certain force being exercised, which, however weak, Mr. Maréchal claims to be not a negligible quantity, so that at high speeds failures might result.

In the Paris, Lyons and Mediterranean system electricity comes into play only to release the armature of the electromagnet of the relay, and to close a circuit on the engine itself, without doing any mechanical work. Through this local circuit of the electro-pneumatic relay (which is fed electrically from the battery on the engine and pneumatically from the receiver) being closed, the compressed air becomes the agent which definitely provides the mechanical power required for unclutching and reclutching.

On the Orléans Railway electrical train signaling is not used, the system preferred consisting of signals placed at a distance in advance of the danger point, the setting of which at "danger" is revealed by the explosion of two cartridges placed automatically on the track when the signal is set at "danger." If on account of atmospheric conditions or a moment's inattention a driver does not notice the signal by the side of the line, he will be warned of its presence at the moment he passes the post by the explosion of the two cartridges which the signal has guided on the rails when turned to "danger." The report produced by the explosion of the cartridges is so loud that it is impossible for it to be overlooked. This system, therefore, has the advantage not only of warning the driver himself of the presence of a signal, but also the officials, and even passengers on the train.—*The Daily Telegraph.*

Heredity—IV.

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Concluded from Scientific American Supplement No. 2021, Page 195, September 26, 1914

To all these great biological problems that modern society must sooner or later face there are many aspects besides the obvious ones. Infant mortality we are asked to lament without the slightest thought of what the world would be like if the majority of these infants were to survive. The decline in the birth-rate in countries already over-populated is often deplored, and we are told that a nation in which population is not rapidly increasing must be in a decline. The slightest acquaintance with biology, or even school-boy natural history, shows that this inference may be entirely wrong, and that before such a question can be decided in one way or the other, hosts of considerations must be taken into account. In normal stable conditions population is stationary. The laity never appreciates, what is so clear to a biologist, that the last century and a quarter, corresponding with the great rise in population, has been an altogether exceptional period. To our species this period has been what its early years in Australia were to the rabbit.

The exploitation of energy-capital of the earth in coal, development of the new countries, and the consequent pouring of food into Europe, the application of antiseptics, these are the things that have enabled the human population to increase. I do not doubt that if population were more evenly spread over the earth it might increase very much more; but the essential fact is that under any stable conditions a limit must be reached. A pair of wrens will bring off a dozen young every year, but each year you will find the same number of pairs in your garden. In England the limit beyond which, under present conditions of distribution, increase of population is a source of suffering rather than of happiness has been reached already. Younger communities living in territories largely vacant are very probably right in desiring and encouraging more population. Increase may, for some temporary reason, be essential to their prosperity. But those who live, as I do, among thousands of creatures in a state of semi-starvation will realize that too few is better than too many, and will acknowledge the wisdom of Ecclesiasticus who said "Desire not a multitude of unprofitable children."

But at least it is often urged that the decline in the birth-rate of the intelligent and successful sections of the population—I am speaking of the older communities—is to be regretted. Even this cannot be granted without qualification. As the biologist knows, differentiation is indispensable to progress. If population were homogeneous civilization would stop. In every army the officers must be comparatively few. Consequently, if the upper strata of the community produce more children than will recruit their numbers some must fall into the lower strata and increase the pressure there. Statisticians tell us that an average of four children under present conditions is sufficient to keep the number constant, and as the expectation of life is steadily improving we may perhaps contemplate some diminution of that number without alarm.

In the study of history biological treatment is only beginning to be applied. For us the causes of the success and failure of races are physiological events, and the progress of man has depended upon a chain of these events, like those which have resulted in the "improvement" of the domesticated animals and plants. It is obvious, for example, that had the cereals never been domesticated cities could scarcely have existed. But we may go further, and say that in temperate countries of the Old World (having neither rice nor maize) populations concentrated in large cities have been made possible by the appearance of a "thrashable" wheat. The ears of the wild wheats break easily to pieces, and the grain remains in the thick husk. Such wheat can be used for food, but not readily. Ages before written history began, in some unknown place, plants, or more likely a plant, of wheat lost the dominant factor to which this brittleness is due, and the recessive, thrashable wheat resulted. Some man noticed this wonderful novelty, and it has been disseminated over the earth. The original variation may well have occurred once only, in a single germ-cell.

So must it have been with Man. Translated into terms of factors, how has that progress in control of nature which we call civilization been achieved? By the sporadic appearance of variations, mostly, perhaps all, consisting in a loss of elements, which inhibit the free working of the mind. The members of civilized communities, when they think about such things at all, imagine the process a gradual one, and that they themselves are active agents in it. Few, however, contribute anything but their labor; and except in so far as they have freedom to adopt and imitate, their physiological composition is that of an earlier order of beings. Annul the work of a few hundreds—I might almost say scores—of men, and on what plane of civilization should we be? We should not have advanced beyond the mediæval stage without printing, chemistry, steam, electricity, or surgery worthy the name. These things are the contributions of a few excessively rare minds. Galton reckoned those to whom the term "illustrious" might be applied as one in a million, but in that number he is, of course, reckoning men famous in ways which add nothing to universal progress. To improve by subordinate invention, to discover details missed, even to apply knowledge never before applied, all these things need genius in some degree, and are far beyond the powers of the average man of our race; but the true pioneer, the man whose penetration creates a new world, as did that of Newton and of Pasteur, is inconceivably rare. But for a few thousands of such men, we should perhaps be in the Palæolithic era, knowing neither metals, writing, arithmetic, weaving, nor pottery.

In the history of art the same is true, but with this remarkable difference, that not only are gifts of artistic creation very rare, but even the faculty of artistic enjoyment, not to speak of higher powers of appreciation, is not attained without variation from the common type. I am speaking, of course, of the non-Semitic races of modern Europe, among whom the power, whether of making or enjoying works of art, is confined to an insignificant number of individuals. Appreciation can in some degree be simulated, but in our population there is no widespread physiological appetite for such things. When detached from the centers where they are made by others most of us pass our time in great contentment, making nothing that is beautiful, and quite unconscious of any deprivation. Musical taste is the most notable exception, for in certain races—for example, the Welsh and some of the Germans—it is almost universal. Otherwise artistic faculty is still sporadic in its occurrence. The case of music well illustrates the application of genetic analysis to human faculty. No one disputes that musical ability is congenital. In its fuller manifestation it demands sense of rhythm, ear, and special nervous and muscular powers. Each of these is separable and doubtless genetically distinct. Each is the consequence of a special departure from the common type. Teaching and external influences are powerless to evoke these faculties, though their development may be assisted. The only conceivable way in which the people of England, for example, could become a musical nation would be by the gradual rise in the proportional numbers of a musical strain or strains until the present type became so rare as to be negligible. It by no means follows that in any other respect the resulting population would be distinguishable from the present one. Difficulties of this kind beset the efforts of anthropologists to trace racial origins. It must continually be remembered that most characters are independently transmitted and capable of such recombination. In the light of mendelian knowledge the discussion whether a race is pure or mixed loses almost all significance. A race is pure if it breeds pure and not otherwise. Historically we may know that a race like our own was, as a matter of fact, of mixed origin. But a character may have been introduced by a single individual, though subsequently it becomes common to the race. This is merely a variant on the familiar paradox that in the

[a] An address delivered at Sydney, Australia, by Prof. William Bateson, M.A., F.R.S., President, before the British Association for the Advancement of Science.

course of time if registration is accurate we shall all have the same surname. In the case of music, for instance, the gift, originally perhaps from a Welsh source, might permeate the nation, and the question would then arise whether the nation, so changed, was the English nation or not.

Such a problem is raised in a striking form by the population of modern Greece, and especially of Athens. The racial characteristics of the Athenian of the fifth century B. C. are vividly described by Galton in "Hereditary Genius." The fact that in that period a population, numbering many thousands, should have existed, capable of following the great plays at a first hearing, reveling in subtleties of speech, and thrilling with passionate delight in beautiful things, is physiologically a most singular phenomenon. On the basis of the number of illustrious men produced by that age Galton estimated the average intelligence as at least two of his degrees above our own, differing from us as much as we do from the negro. A few generations later the display was over. The origin of that constellation of human genius which then blazed out is as yet beyond all biological analysis, but I think we are not altogether without suspicion of the sequence of the biological events. If I visit a poultry-breeder who has a fine stock of thoroughbred game fowls breeding true, and ten years later—that is to say ten fowl-generations later—I go again and find scarcely a recognizable game-fowl on the place, I know exactly what has happened. One or two birds of some other or of no breed must have strayed in and their progeny been left undestroyed. Now in Athens we have many indications that up to the beginning of the fifth century so long as the phratries and gentes were maintained in their integrity there was rather close endogamy, a condition giving the best chance of producing a homogeneous population. There was no lack of material from which intelligence and artistic power might be derived. Sporadically these qualities existed throughout the ancient Greek world from the dawn of history, and, for example, the vase-painters, the makers of the Tanagra figurines, and the gem-cutters were presumably pursuing family crafts, much as are the actor-families[1] of England or the professorial families of Germany at the present day. How the intellectual strains should have acquired predominance we cannot tell, but in an in-breeding community homogeneity at least is not surprising. At the end of the sixth century came the "reforms" of Cleisthenes (507 B. C.), which sanctioned foreign marriages and admitted to citizenship a number not only of resident aliens, but also of manumitted slaves. As Aristotle says, Cleisthenes legislated with the deliberate purpose of breaking up the phratries and gentes, in order that the various sections of the population might be mixed up as much as possible, and the old tribal associations abolished. The "reform" was probably a recognition and extension of a process already begun; but is it too much to suppose that we have here the effective beginning of a series of genetic changes which in a few generations so greatly altered the character of the people? Under Pericles the old law was restored (451 B. C.), but losses in the great wars led to further laxity in practice, and though at the end of the fifth century the strict rule was re-enacted that a citizen must be of citizen-birth on both sides, the population by that time may well have become largely mongrelized.

Let me not be construed as arguing that mixture of races is an evil: far from it. A population like our own, indeed, owes much of its strength to the extreme diversity of its components, for they contribute a corresponding abundance of aptitudes. Everything turns on the nature of the ingredients brought in, and I am concerned solely with the observation that these genetic disturbances lead ultimately to great and usually unforeseen changes in the nature of the population.

Some experiments of this kind are going on at the present time, in the United States, for example, on a very large scale. Our grandchildren may live to see the characteristics of the American population entirely altered by the vast invasion of Italian and other South European elements. We may expect that the Eastern States, and especially New England, whose people still exhibit the fine Puritan qualities with their appropriate limitations, absorbing little of the alien elements, will before long be in feelings and aptitudes very notably differentiated from the rest. In Japan, also, with the abolition of the feudal system and the rise of commercialism, a change in population has begun which may be worthy of the attention of naturalists in that country. Till the revolution the Samurai almost always married within their own class, with the result, as I am informed, that the caste had fairly recognizable features. The changes of 1868 and the consequent impoverishment of the Samurai have brought about a beginning of disintegration which may not improbably have perceptible effects.

[1] For fables of these families, see the Supplement to *Who's Who in the Theater.*

How many genetic vicissitudes has our own peerage undergone! Into the hard-fighting stock of mediæval and Plantagenet times have successively been crossed the cunning shrewdness of Tudor statesmen and courtiers, the numerous contributions of Charles II and his concubines, reinforcing peculiar and persistent attributes which popular imagination especially regards as the characteristic of peers, ultimately the heroes of finance and industrialism. Definitely intellectual elements have been sporadically added, with rare exceptions, however, from the ranks of lawyers and politicians. To this aristocracy art, learning, and science have contributed sparse ingredients, but these mostly chosen for celibacy or childlessness. A remarkable body of men, nevertheless; with an average "horse-power," as Samuel Butler would have said, far exceeding that of any random sample of the middle-class. If only man could be reproduced by budding what a simplification it would be! In vegetative reproduction heredity is usually complete. The Washington plum can be divided to produce as many identical individuals as are required. If, say, Washington, the statesman, or preferably King Solomon, could similarly have been propagated, all the nations of the earth could have been supplied with ideal rulers.

Historians commonly ascribe such changes as occurred in Athens, and will almost certainly come to pass in the United States, to conditions of life and especially to political institutions. These agencies, however, do little unless they are such as to change the breed. External changes may indeed give an opportunity to special strains, which then acquire ascendency. The industrial developments which began at the end of the eighteenth century, for instance, gave a chance to strains till then submerged, and their success involved the decay of most of the old aristocratic families. But the demagogue who would argue from the rise of the one and the fall of the other that the original relative positions were not justifiable altogether mistakes the facts.

Conditions give opportunities but cause no variations. For example, in Athens, to which I just referred, the universality of cultivated discernment could never have come to pass but for the institution of slavery which provided the opportunity, but slavery was in no sense a cause of that development, for many other populations have lived on slaves and remained altogether inconspicuous.

The long-standing controversy as to the relative importance of nature and nurture, to use Galton's "convenient jingle of words," is drawing to an end, and of the overwhelmingly greater significance of nature there is no longer any possibility of doubt. It may be well briefly to recapitulate the arguments on which naturalists rely in coming to this decision both as regards races and individuals. First as regards human individuals, there is the common experience that children of the same parents reared under conditions sensibly identical may develop quite differently, exhibiting in character and aptitudes a segregation just as great as in their colors or hair-forms. Conversely all the more marked aptitudes have at various times appeared and not rarely reached perfection in circumstances the least favorable for their development. Next, appeal can be made to the universal experience of the breeder, whether of animals or plants, that strain is absolutely essential, that though bad conditions may easily enough spoil a good strain, yet that under the best conditions a bad strain will never give a fine result. It is faith, not evidence, which encourages educationists and economists to hope so greatly in the ameliorating effects of the conditions of life. Let us consider what they can do and what they cannot. By reference to some sentences in a charming though pathetic book, "What Is, and What Might Be," by Mr. Edmond Holmes, which will be well known in the educational section, I may make the point of view of us naturalists clear. I take Mr. Holmes's pronouncement partly because he is an enthusiastic believer in the efficacy of nurture as opposed to nature, and also because he illustrates his views by frequent appeals to biological analogies which help us to a common ground. Wheat badly cultivated will give a bad yield, though, as Mr. Holmes truly says, wheat of the same strain in similar soil well cultivated may give a good harvest. But, having witnessed the success of a great natural teacher in helping unpromising peasant children to develop their natural powers, he gives us another botanical parallel. Assuming that the wild bullace is the origin of domesticated plums, he tells us that by cultivation the bullace can no doubt be improved so far as to become a better bullace, but by no means can the bullace be made to bear plums. All this is sound biology; but translating these facts into the human analogy, he declares that the work of the successful teacher shows that with man the facts are otherwise, and that the *average rustic* child, whose normal ideal is "bullacehood," can become the rare exception, developing to a stage corresponding with that of the plum. But the naturalist knows exactly where the parallel is at fault. For the wheat and the bullace are both breeding approximately true, whereas the human crop, like jute and various cottons, is in a state of polymorphic mixture. The population of many English villages may be compared with the crop which would result from sowing a bushel of kernels gathered mostly from the hedges, with an occasional few from an orchard. If anyone asks how it happens that there are any plum-kernels in the sample at all, he may find the answer perhaps in spontaneous variation, but more probably in the appearance of a long-hidden recessive. For the want of that genetic variation, consisting probably, as I have argued, in loss of inhibiting factors, by which the plum arose from the wild form, neither food, nor education, nor hygiene can in any way atone. Many wild plants are half-starved through competition, and transferred to garden soil they grow much bigger; so good conditions might certainly enable the bullace population to develop beyond the stunted physical and mental stature they commonly attain, but plums they can never be. Modern statesmanship aims rightly at helping those who have got sown as wildings to come into their proper class; but let not any one suppose such a policy democratic in its ultimate effects, for no course of action can be more effective in strengthening the upper classes while weakening the lower.

In all practical schemes for social reform the congenital diversity, the essential polymorphism of all civilized communities must be recognized as a fundamental fact, and reformers should rather direct their efforts to facilitating and rectifying class-distinctions than to any futile attempt to abolish them. The teaching of biology is perfectly clear. We are what we are by virtue of our differentiation. The value of civilization has in all ages been doubted. Since, however, the first variations were not strangled in their birth, we are launched on that course of variability of which civilization is the consequence. We cannot go back to homogeneity again, and differentiated we are likely to continue. For a period measures designed to create a spurious homogeneity may be applied. Such attempts will, I anticipate, be made when the present unstable social state reaches a climax of instability, which may not be long hence. Their effects can be but evanescent. The instability is due not to inequality, which is inherent and congenital, but rather to the fact that in periods of rapid change like the present, convection-currents are set up such that the elements of the strata get intermixed and the apparent stratification corresponds only roughly with the genetic. In a few generations under uniform conditions these elements settle in their true levels once more.

In such equilibrium is content most surely to be expected. To the naturalist the broad lines of solution of the problems of social discontent are evident. They lie neither in vain dreams of a mystical and disintegrating equality, nor in the promotion of that malignant individualism which in older civilizations has threatened mortification of the humbler organs, but rather in a physiological co-ordination of the constituent parts of the social organism. The rewards of commerce are grossly out of proportion to those attainable by intellect or industry. Even regarded as compensation for a dull life, they far exceed the value of the services rendered to the community. Such disparity is an incident of the abnormally rapid growth of population and is quite indefensible as a permanent social condition. Nevertheless capital, distinguished as a provision for offspring, is a eugenic institution; and unless human instinct undergoes some profound and improbable variation, abolition of capital means the abolition of effort; but as in the body the power of independent growth of the parts is limited and subordinated to the whole, similarly in the community we may limit the powers of capital, preserving so much inequality of privilege as corresponds with physiological fact.

At every turn the student of political science is confronted with problems that demand biological knowledge for their solution. Most obviously is this true in regard to education, the criminal law, and all those numerous branches of policy and administration which are directly concerned with the physiological capacities of mankind. Assumptions as to what can be done and what cannot be done to modify individuals and races have continually to be made, and the basis of fact on which such decisions are founded can be drawn only from biological study.

A knowledge of the facts of nature is not yet deemed an essential part of the mental equipment of politicians; but as the priest, who began in other ages as medicine-man, has been obliged to abandon the medical parts of his practice, so will the future behold the schoolmaster, the magistrate, the lawyer, and ultimately the statesman, compelled to share with the naturalist those functions which are concerned with the physiology of race.

Electrical Driving for Rolling Mills—I*

Its Adaptation to Existing Steam-Driven Plants

By L. Rothera

THE question of the application of electrical driving to existing rolling mills is one which is of the greatest importance where steel, iron and other metal works have been in existence for a considerable number of years, and where the question is not the best method of putting up new works, but the best method of making an old works so economical that it can compete successfully with others which have only within a later period entered this field, and have, consequently, been able to make use of the latest advancements of science.

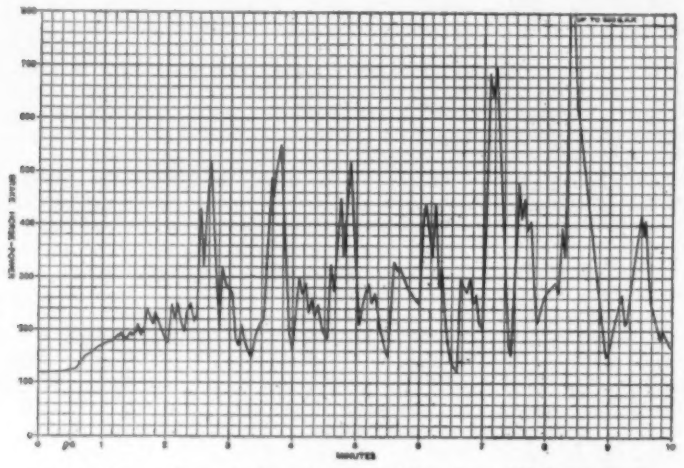


Fig. 1.—Power-demand of a sheet mill driven by a 600 horse-power motor.

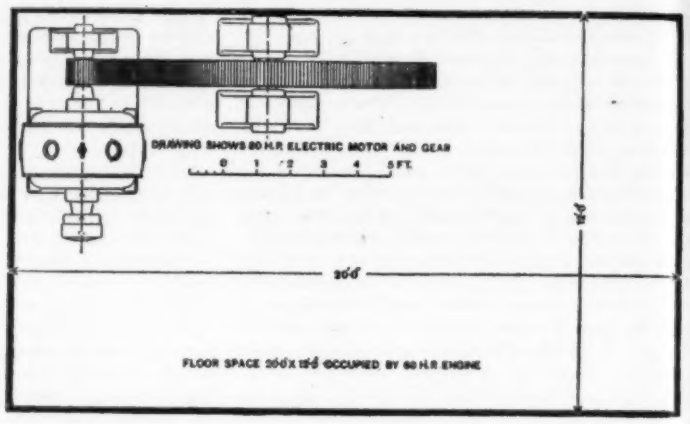


Fig. 2.—Relative floor space taken up by a 60 horse-power engine and an 80 horse-power motor.

The subject of this paper can perhaps best be dealt with by dividing it up into two parts:

(I.) The conditions which render the application of the electrical drive desirable.

(II.) The method of application of the drive.

Taking first the considerations which render the application desirable, there are a number of conditions, any one of which may prove the deciding factor in the employment of electricity. Perhaps four such considerations are the most important, namely:

1. Economy of running.
2. Improved drive.
3. Considerations of space.
4. Greater use of existing plant.

While it is quite possible that any one of the above considerations may in itself prove sufficient to warrant a change over from a steam to an electrical drive, yet it is more often a combination of the four, together with other considerations not mentioned, which makes the employment of an electrical drive the only one to be considered when a change is necessary.

1. *Economy of Running.*—Dealing first with the economy of running, that is, cost of power per ton rolled, it is, of course, not possible to make any general statement to the effect that in every case the electrical drive will prove more economical than the steam drive, as this depends entirely on local conditions, which differ to such an extent that it is only possible in a paper such as this to indicate a few of the more important ones. Instancing some of these:

The first main factor is the cost of electrical energy. The cost for power will vary very widely in accordance with the method of generating power, and in steel and iron works particularly the question must often be considered as to whether a central station in the works themselves, driven either by gas, live steam raised by hand-firing, steam raised from waste heat, or exhaust steam, is not the most economical method of obtaining the necessary electric power. A very low figure has been, and is being, obtained under certain conditions which represent the most economical method at present known of using available facilities. The method referred to is the employment of blast-furnace gas, coke-oven gas, or a mixture of the two, to drive gas-engines for generating electric power, and using the power thus obtained for driving the steel works plant by electric motors. When it is realized that between two and three times the power is available from the gas so employed to that obtainable if the gas is burnt under boilers for the purpose of raising steam, the economy of this method is self-evident.

The charges made by supply companies vary, naturally, within wide limits, depending largely on the size of the station, cost of coal, etc., and also on the nature of the demand for power; that is, whether night or day load, and whether continuous or not, and also on the quantity of power required per annum.

It is, of course, manifest that with a low cost of purchased power there is little, if any, advantage in putting down a central station in the works themselves to be driven by steam, unless the necessary steam is available from waste heat boilers.

Figs. 4 and 5.—150 horse-power motor weighing 4½ tons mounted under roof and driving down through ropes to the mill below.

Fig. 6.—View of the four mills driven by above motor.

When waste heat is available for raising steam, or exhaust steam can be employed, the conditions are quite altered, as when the coal cost, which represents usually over one half of the total cost of power generation, can be ignored, the cost of generation is so low that any works would be well advised to install their own generating plant.

The cost of driving by steam varies fairly considerably in different parts of the country, depending on the cost of coal available, cost of water, labor and other charges, but the fact that motors have been put down, even in cases where power has to be purchased at the highest price, goes far to prove that either the cost of driving by steam is equal to, or greater than, the cost of driving by electricity, or that some of the conditions mentioned later have proved so weighty that the electrical drive has been judged the most satisfactory one to employ.

The second factor on which the economy largely depends is the lay-out of the works. Let us consider the case of a works which originally started in a fairly small way, but which has extended very largely, and in which the boiler plant has remained centralized. The natural effect of this would be a very large number of long steam-pipe lines, all of them acting the part of condensers, and probably a number of them leaking very considerably, this condensation and leakage taking place continuously, whether the engines, which the pipe-lines supply, are working or not. These conditions will, to a large extent, hold even in the case of a works where there are several boiler stations, and the quantity of coal used per year in making up for pipe-line losses and wastage is a very heavy factor in the year's coal bill.

As against this wasteful condition must be taken the economical method of electric power transmission, which is carried out by small cables which can be put up anywhere quite out of the way, and in which no loss takes place when the machines to which they convey power are not running, and in which only a small fraction of loss takes place when the machines are running.

In an old works, moreover, there will be a large number of auxiliary machines driving shears, saws, punching machines, etc., which are working under most uneconomical conditions, being nearly in every case non-condensing, and often almost indistinguishable when working, due to the steam leakage taking place around them.

Contrasting the case of a small motor drive, where the efficiency is practically 88 per cent and where power is being generated under the most economical conditions, the gain in economy is enormous, and it is now an acknowledged fact that under anything like reasonable conditions of electric power cost the auxiliary plant in a mill is much better driven by means of electric motors.

A third factor is the class of work done. As is well known, the steam-engine, while efficient on steady continuous load, becomes very inefficient on a widely fluctuating load. This is a condition which is not nearly so pronounced in the case of an electric motor drive, due to the fact that the efficiency over a very wide range, say from half-load up to 100 per cent overload, varies only to the extent of 2 or 3 per cent, while the steam consumption of an engine may vary as much as 7 to 9 per cent. When there is a considerable length of piping in conjunction with the engine the inefficiency in the latter case is more pronounced, as continual radiation losses are taking place from the pipe-line whether the engine is working or standing still. The amount of steam consumed per useful horse-power will be very materially increased through this source of loss. It may thus be generally stated that the greater the fluctuations in the load, the more advantageous the electrical drive appears. As the load on a rolling mill is, in most cases, a very variable one, varying possibly from practically no-load to nearly 100 per cent overload, the economy of the efficient electrical drive is apparent.

As an instance of this, let us take the case of a sheet mill where the average power-demand, as is shown very clearly from the Fig. 1, represents approximately one third of the normal power of the motor, while the peak load represents practically 50 per cent overload on the motor. This curve is an experimental one taken on a mill driven by a 600 horse-power motor when working

* Paper read before the Institution of Mechanical Engineers.

under normal working conditions. Assuming the maximum overload which the engine would take to be 25 per cent, the normal horse-power of the engine would have to be chosen at 720 horse-power to deal with the peak loads, so that one third load on the motor, namely, 200 horse-power, would represent only about 28 per cent of the normal engine power. The efficiency of the motor at third load would be approximately 4 per cent less than at full load, while the steam consumption of the engine would be increased at least 12 per cent, not taking into account the losses in the pipe-line, which are considerable, due to the fact that the steam-piping has to be designed of sufficient capacity to take the full rush of steam to meet the overload condition on the engine.

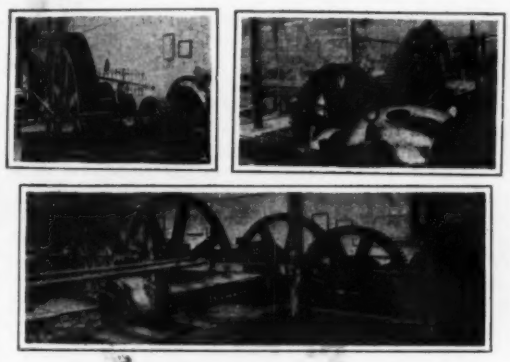
Under the question of economy must also be taken the cost of supervision of the running plant. In a large works where there are a number of engines, the running and oiling of the same becomes the task of a considerable number of men. This number can be very materially reduced where motor drives are employed, owing to the fact, that, if properly designed, the motors will run for long periods without any attention whatever, and inspection once a day is all that is necessary. One electrician, to start up the plant in the morning and to pay a periodical visit to the motors throughout the day, can deal with almost any number of machines. Contrast this with the necessity of one driver for each large engine, and a number of greasers for the small engines, and the saving to be effected per annum is very considerable.

2. *Improved Drive.*—With regard to the question of improved drive, it is an undisputed fact that a steady uniform turning moment produces a better class of rolled material than is the case with a pulsating drive. Even under the best conditions of engine practice a considerable variation in the turning moment is bound to occur, and in this respect the electric motor with its uniform constant torque is far superior.

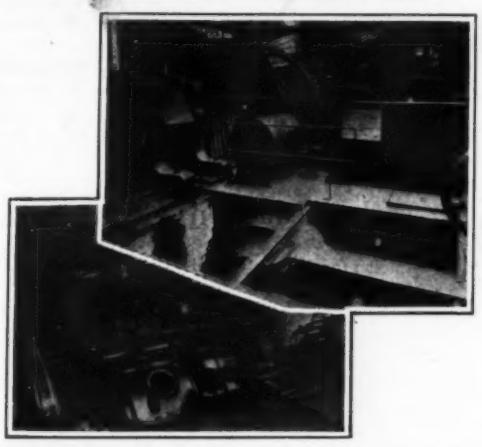
Another feature very noticeable with the motor drive is the faster working consequent on the fact that, with the even turning moment, there is not the same tendency for the rolls to fail to grip the metal. Also, due to the overload capacity of the motor being in excess of that of an engine, the drop in speed while the metal is passing through the rolls is much less with the electric drive than with the steam drive, and in fact the amount of the drop can be regulated at will in the former case; this results in a higher average speed of rolling and consequent increased output from the mill.

Again, in rolling-mill work, one of the essentials of the drive is that of a good overload capacity. The modern electric motor will take a momentary peak load up to 100 per cent in excess of its normal load without any risk of injury, and is thus enabled to pull a piece of metal through the rolls when an engine of the same normal power would fail to do so, with consequent delay and loss on the mill. The effect of this property of the electric motor is that, when making a comparison between the cost of an electrical, as compared with a steam drive, it is not fair to take into account the same size of the steam-engine and of motor. A larger normal horse-power of the steam-engine would be necessary to give the same maximum turning moment conditions which the motor would give.

The effect of this increase in the size of the engine is to raise the normal horse-power as compared with the average horse-power required, with resulting worse steam consumptions, as is clearly shown above. In addition, larger steam-piping would be necessary to enable the full overload to be carried, which again would prove an increased source of loss.



Figs. 7, 8, and 9.—Motor 250 horse-power, 300 revolutions, driving eleven pairs of rolls.



Figs. 10 and 11.—Two motors (275 horse-power and 100 horse-power) working in a pit below the floor. Gear drive to sheet mill.

Fig. 12.—Direct-coupled electrical drive by means of long intermediate spindle.

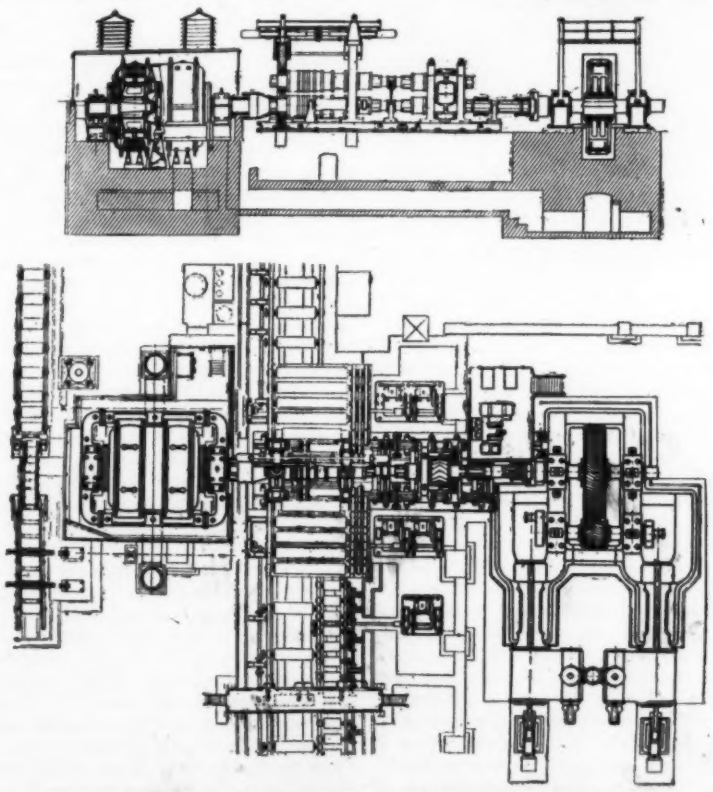


Fig. 3.—Reversing mill: converted from steam to electrical drive, the steam engine being retained for use if necessary.
Scale 25 feet = 1 inch.

Another point in favor of the electrical drive is the ease of starting and stopping the plant, so that, in many cases, it is found practicable when the mill is idle for short periods to shut the motor down, whereas it would not be considered in the case of a steam-engine on account of the labor involved.

A further feature, which is also in favor of the electrical drive, and the importance of which is perhaps only appreciated by those who are acquainted with the electrical drive, is the ease of determining for every pass the power being demanded to roll. Electrical instruments will show, with great exactitude, the demand for power at any moment, and it is possible by perhaps somewhat varying the draughting of the rolls, in accordance with these readings, to materially reduce the energy consumption per ton rolled.

3. *Considerations of Space.*—This condition is, of course, of particular weight in the case of works situated in the center of the town where it may be desired either to put down new mills, or to modify existing mills, to allow of larger operations being carried out. This condition is of such importance that in many cases it has been able to overcome the drawback of a heavy charge for power. When the size of a motor of moderate speed is taken and compared with the size of engine of the same power, this advantage is very clearly seen. The illustration, Fig. 2, shows the floor space taken up by an engine which gives a maximum horse-power of 60, and superimposed to the same scale is shown the 80 horse-power motor, which is replacing the engine.

Fig. 4 shows an arrangement which has been carried out in the Birmingham district where the 150 horse-power motor, weighing 4½ tons, is mounted right up under the roof, driving down through ropes on to the mill below. Fig. 5 shows the drive on to the mills, and Fig. 6 a view of the four mills driven from this motor. This last view shows very clearly how full the works are, and how important it is to save every square foot of space available. In this particular instance the doing away of the old beam-engine and the replacing of the same by the motor saved a floor area of over 40 square yards, and this space has been fully utilized by the installation of additional machinery.

Fig. 7 shows another drive in the Birmingham district where a motor has been put down to replace an engine drive, and Fig. 8 shows another view which gives a very clear idea as to the method of driving the eleven pairs of rolls which are worked from this motor. Fig. 9 shows the site of the old engine, the crankshaft being where the coupling-box is seen in the photo, and in this case an area of no less than 76 square yards was saved by the change-over. The motor is of 250 horse-power running at 300 revolutions per minute.

Figs. 10 and 11 show another arrangement which has been adopted in the Birmingham district where two motors of 275 horse-power and 100 horse-power respectively have been installed for driving some sheet mills. There was no space available on the ground level, and the result has been that the motors have been put in a pit below the floor and boarded over. The space is so restricted between the mills that the men actually work on the boards above the motors. A suitable gear drive has been arranged, as can be seen by the illustration, between the motor and the mill.

4. *Increased Power.*—A case very often arises where a mill manager is anxious to enlarge the power of his driving engines, and the question then arises as to how this is to be done. In a great many cases the amount of steam available would not be sufficient to allow of the installation of larger engines without expensive alterations to boiler plant, and it is in such a case that the installation of electrical plant can show very favorably. Given below is an example based on actual figures illustrating this point. The case is one of an iron works where a proportion of the steam used is raised from waste heat boilers over puddling furnaces, and the remainder of the steam required is raised by hand-firing. The question may arise as to how:

(1) The hand-firing can be dispensed with, and

(2) An increased power obtained.

Assume that the works has four rolling mills, consisting of a forge train, two merchant mills, and a sheet mill, the mills being driven by two engines, one driving the forge and one merchant mill, the other driving the sheet mill, and the other merchant mill. Let us take an output of 30 tons of puddled bars from the forge train, 18 tons of flats, rounds, etc., per turn from the merchant mill attached to this engine, 8 tons per turn from the sheet mill, and 12 tons of rounds from this merchant mill. In order to obtain the above output, a total quantity of coal of approximately 1,980 tons per month would be used in the furnaces, and in addition approximately 270 tons of coal under hand-fired boilers. Taking steam evaporation from the furnaces at three times the weight of coal consumed, the steam raised from the furnaces

would be 13,300,000 pounds per month, and from the steam under the boilers, assuming seven times evaporation, 4,240,000 pounds, that is, the total quantity of steam per hour would be 30,000 pounds. The whole of this steam is at present being employed in driving the above two engines, steam-hammers and a few small auxiliary engines.

Suppose it was proposed to replace the engines by an electrical drive, the problem is to find out whether any economy would result. Under the above conditions of output, it can be taken that the total number of units to roll the tonnage mentioned would be approximately 400 kilowatts per hour. In order to deal with this, and also the auxiliary plant, which would perhaps take 70 kilowatts, a 500-kilowatt turbine would be installed. The steam-pressure raised in boilers above puddling furnaces is usually very low, about 40 pounds per square inch, and under these conditions a steam consumption of approximately 20.1 pounds per kilowatt-hour would be necessary, that is, the total quantity of steam required would be 10,500 pounds per hour. The amount of steam produced from the waste heat boilers alone is 23,000 pounds, and taking the steam required for the hammers at 4,000 pounds per hour, there is left available no less than sufficient steam to raise a further 400 kilowatts, and at the same time give a saving in hand-firing of 270 tons of coal per month.

The above figures, which speak for themselves, and which are in no way exaggerated, show conclusively how, under such conditions, by the installation of electrical plant, an extremely large saving per annum can be made, and at the same time a very largely increased power rendered available from steam already existing. An actual instance of this is the case of an iron works where three of the main engines and all the auxiliaries were replaced by motors of very considerably increased power and a central station was put down for supplying them. Since the electrification no fewer than eight hand-fired boilers have been permanently knocked off.

Another interesting case to consider is that of a reversing mill plant in which the roughing and finishing mills are driven from the same engine. Suppose it is desired to increase the output of the mill, a method of doing so is to divide the mill up, driving the finishing mill and roughing mill separately. Assuming that the question of capital cost renders the complete electrification of the mill impossible, then the existing engine can be retained for driving the finishing mill, and under the usual conditions of merchant mill work, the exhaust steam from the reversing mill-engine will be sufficient to generate enough power to drive the roughing mill electrically. While by doing this the output of the mill may be practically doubled, yet the drive will not be so economical as it would be if the whole plant was driven electrically, due to the better steam consumption of a turbine driving a generating set as compared with that of a reversing steam-engine working under rolling-mill conditions, this better economy more than counter-balancing the losses due to the conversion into electrical energy.

The above conditions are, perhaps, particularly favorable for the installation of electrical drive, but there are a very large number of considerations which come into question, which must be very carefully weighed before deciding that the electrical drive will not pay, even if the actual cost of electricity consumed per ton rolled is in excess of the corresponding steam cost; for instance, the cost of maintenance on an electric motor is very much less than that of a steam-engine. The cost of supervision is also very much less. The reduction in the oil consumed per annum is another item which must not be lost sight of, and in one particular case where electrical plant replaced steam drives, the reduction in the oil consumed was 80 per cent. When, in addition to the above advantages, the absence of steam-pipes with their cost of upkeep, and the cleanliness of the electric drive, are remembered, there are many cases where these advantages alone outweigh, perhaps, a slightly increased capital cost, or a power consumption cost, which would appear to be more than that of a steam-engine, when taking into consideration alone the *steam consumption* of the engine.

A point which should always be borne in mind is, that although an engine may be designed to be very economical indeed on full-load, yet the conditions of a rolling mill are such that these conditions are practically never obtained, and the only fair method of comparing the electrical with the steam drive, is to take, in the latter case, the *cost of coal per annum*, and not the steam consumption of the engine, and contrast this with the power cost of the motor.

(*To be concluded.*)

Recent Developments in Marine Propulsion*

The Compound Turbine, with Reduction Gear, and Gas and Oil Engine

During the one hundred years that the reciprocating steam engine has been used for the propulsion of ships, it has been continuously improved in reliability, handiness, and efficiency, and it had no competitor until a little more than a dozen years ago, when the Parsons turbine began to claim attention as a serious rival for the propulsion of high-speed, high-powered ships. The improvements in the efficiency of the reciprocating steam engine have been due to the conjoint effects of improved materials and tools for the construction of the boilers and the engines and to increasing knowledge of the scientific principles relating to the thermal and mechanical problems involved in the design and construction of the engine and its auxiliaries. The introduction of the compound, triple, and quadruple expansion engines, associated in each case with considerable increases in steam pressure, enabled successive and notable increases to be obtained both in the thermal and mechanical efficiencies of the engine, and the successful re-introduction of superheating has rendered it possible still further to reduce the consumption of coal per horse-power hour by from 10 to 20 per cent under favorable conditions.

In all reciprocating engines the piston and other reciprocating parts have to be stopped and started again twice for each revolution of the crankshaft, and the forces transmitted to the bed-plate of the engine, due to the starting and stopping of the reciprocating masses, are so great that unless balanced they cause great vibration of both the engine and of the ship. Increased knowledge has rendered it possible entirely to balance these inertia forces and couples within the engine framing itself, but for a complete balance the minimum number of cranks required is five, although it is possible to get an approximate balance in an engine with four cranks.

In order to get rid of some of the mechanical defects of the reciprocating engine, innumerable inventors have striven to produce a successful type of rotary steam engine, but all these efforts were in vain until Parsons solved the problem by inventing his compound steam turbine. This type of engine consists essentially of one moving part only, the turbine drum, which has only rotational motion, and which therefore can be perfectly balanced. The success of the steam turbine for marine propulsion has been due, not to the reduction of steam and coal consumption, but to the absence of vibration in its working, to the reduction in weight and in space occupied for a given power, to its greater simplicity as a machine, to the lower cost of maintenance, and to the great units of power in which it can be constructed. When the turbine can be arranged to run at its best speed its efficiency is at least equal to, and in many cases greater than, the efficiency of the best reciprocating steam engine; but this speed is much greater than the best speed for a screw propeller. In applying a steam turbine for marine propulsion it was necessary to effect a compromise; the turbines were designed to run at a much lower speed than turbines of the same power used for the driving of dynamos, and the screw propellers were made of smaller diameter, and their speed of rotation was increased as compared with propellers driven by reciprocating engines. These modifications involved larger turbines, with more expansion stages, also a reduction in the efficiencies of the turbine and of the propeller. In spite of these difficulties, the direct connected turbine proved itself to be much superior to the reciprocating steam engine for high-speed, high-powered ships.

Owing to the difficulties which I have indicated, the field of application of the direct-coupled steam turbine has been restricted to high-speed, high-powered ships. In order to render the many advantages of the steam turbine available for small-powered, lower-speed ships, Parsons has introduced helical gearing for connecting high-speed turbines to low-speed propeller shafts, and the results of experience already obtained with these geared turbines are so promising as to render it likely that this system will be largely adopted in the immediate future.

The gear ratio varies with the conditions. In the case of the "Vespasian" this ratio is 20, the turbine running at 1,440 revolutions per minute, and the propeller shaft at 72 revolutions per minute. The shaft horse-power at 73 revolutions per minute was 1,080, and the corresponding speed of the ship was 10.58 knots.

In the case of the twin-screw channel steamers "Normania" and "Hantonia," each of which is fitted with geared turbines giving 5,000 shaft horse-power at 19.7 knots, there are four turbines, two of which run at 2,000 revolutions and the other two at 1,400 revolutions, while the propeller shafts both run at 310 revolutions. The results of measurements show that the geared turbined ship "Cairnross" used 15 per cent less coal than her sister ship the "Cairngowan," which is fitted with triple-expansion engines.

The efficiency of Parsons helical gearing is stated to be 98½ per cent, so that the friction loss due to its use is only 1½ per cent, whereas the gain at the turbine is many times this. The high efficiency of the gearing is due to the accuracy with which the teeth are formed, also to the effective means adopted for lubricating the teeth. A spray of oil is continually showered upon the teeth as they enter into mesh with one another, and the resulting films of oil prevent the teeth coming into contact with each other, and the conditions are therefore the same as in a well-lubricated bearing.

In a few ships, a steam turbine has been coupled up in series with quadruple-expansion engines, thus enabling the expansion to be carried further than can be effected in a reciprocating engine, and it is said that this combination has effected a reduction of 20 per cent in steam consumption as compared with the quadruple-expansion engine alone. The complexity of this combination and the successful introduction of the geared turbine will, I think, prevent this combination being widely adopted.

Another method which is being developed as a reducing gear between steam turbines and propeller shaft is the Föttinger hydraulic transmitter.

This transmitter consists essentially of a centrifugal pump and a water turbine combined within the same casing in such a way as to reduce the losses to a minimum. The efficiency of this type of reducing gear is not so high as that of the Parsons gear, but it is stated that in the case of large powers the efficiency may be as high as 90 per cent. This gear has the advantage that it is reversible, and therefore it obviates the need for the go-astern steam turbines and the direction of rotation of the driving steam turbine is never reversed. It thus gets rid of one cause of blade stripping such as occurred, for instance, in the turbines of the "Lusitania." It also enables the power for going astern to be as much as 80 per cent of the go-ahead power, which is very much greater than that usually provided in the go-astern turbines. The maximum power transmitted to one shaft by this gear up to the present is 10,200 horse-power, and the reversal can be effected in from 10 to 12 seconds. This gear is being applied on a German turbine ship of 23,000 horse-power, and the efficiency guaranteed is 90 per cent, but a better result than this is expected. This gear is used on the Holtzapfel gas-propelled vessel, also in connection with Diesel engines. The velocity ratio possible with this gear is only about 6 to 1 with a single-stage arrangement, but with a three-stage combination it may be as high as 30 to 1.

No notable improvements have been made in recent years in the design or in the efficiency of marine boilers, excepting in the case of those used in warships, which are now always of the water-tube type. This type of boiler has not found favor in the ships of the mercantile marine, mainly because it requires more skilled and more careful attention than the ordinary type of marine boiler and because it is of greater importance with it to prevent oil and sea-water being admitted to the boilers. Improvements in condensers and the adoption of the steam turbine reduce these difficulties, and it is likely that for high-powered ships the water-tube boiler will in the near future displace the ordinary type of boiler, because its weight and the space occupied are considerably reduced by its adoption.

Recently, a new type of boiler has been introduced by Prof. Bone which enables great reductions to be made in the size, weight, and cost of boilers. This boiler is of the ordinary multi-tubular type, but it contains neither furnaces nor combustion chambers of the usual type. The tubes are packed with a refractory material and the fuel, gas or oil spray, is burned within the tubes of the boiler. The refractory material greatly increases the rate of combustion and also greatly increases the rate of evaporation. In one boiler the rate of evaporation was over 20 pounds per square foot of tube surface per hour, which is from three to four times as great as that usually attained in marine boilers, and it is stated that the efficiency was over 90 per cent, as compared with from 70 to 80 per cent in boilers of the ordinary type. This boiler cannot, unfortunately, be fired with coal direct. The coal must first be gasified and the gas must be thoroughly cleansed of ash and tar. This boiler therefore would be of no use for marine purposes were it not for the fact that fuel oil when suitably sprayed may be used in conjunction with it. If the results already obtained with this type of boiler are proved to be attainable under regular working conditions at sea with oil fuel, it may displace the water-tube boiler for warships.

* Abstract of a lecture delivered by Prof. W. H. Watkinson at the Liverpool University. Reproduced from *The Engineer*.

The following comparisons between quadruple-expansion reciprocating engines, ordinary turbines, and geared turbines may be of interest:

	Vessel 480 feet long, trial speed 14¼ knots.		Vessel 600 feet long, trial speed 19½ knots.	
	Quadruple reciprocating.	Geared turbines.	Ordinary turbines.	Geared turbines.
Total weight of machinery in tons	1,345	1,050	3,000	2,910
Weight of coal per hour, tons	4.8	4.1	13.6	12.5
Area of engine-room	1,950	1,950	5,020	3,990
Area of boiler-rooms, without bunkers	2,110	2,020	6,400	6,160

The steam engine, whether of the reciprocating or of the turbine type, has a much lower possible efficiency than the internal combustion engine. If coal is burned without excess of air, the temperature attainable is about 5,200 deg. Fahr., and a perfect engine working between this temperature limit and the temperature of the atmosphere would convert 91 per cent of the heat into work. With a perfect boiler, the weight of coal required per indicated horse-power hour would be only one fifth of a pound, and the weight of oil required would be only 0.133 of a pound.

The maximum temperature attained in the cylinders of gas and oil engines is about 3,000 deg. Fahr., and a perfect cycle working between this temperature and atmospheric temperature would convert 85 per cent of the heat into work, and would use only 0.159 of a pound of oil per indicated horse-power hour. The thermal efficiency actually attained in Diesel engines is about 42 per cent, and the weight of oil per indicated horse-power hour is about one third of a pound, and the weight of oil per brake horse-power hour is about 0.4 of a pound.

The great handicap of the steam engine is the big drop in temperature between the furnace and the steam. The best result yet attained with a steam engine and boiler is a combined efficiency of 17 per cent, and, including engine friction, 15 per cent. It is usually very considerably less than this. With the above efficiency, the weight of coal used per indicated horse-power is equal to 1.08 pound per hour, and the weight of coal per brake horse-power hour works out at 1.22 pound.

The greater possibilities of the internal combustion engine as compared with the steam engine and the results already achieved with marine Diesel engines must compel increasing attention to be given to the development of the internal combustion engine.

With internal combustion engines, the fuel may be either coal or oil, but at present there is no gas producer available suitable for marine purposes, and very few men appear to be devoting themselves to the solution of this important problem. The line of least resistance for marine work is the use of oil fuel, as this does not involve the use of gas producers and their accessories.

The fact, established by actual experience at sea, that the weight of oil required per brake horse-power hour by Diesel engines is only from a quarter to one fifth the weight of coal required with steam engines, whether of the reciprocating or of the turbine type, enables oil fuel to be used with commercial success even when the price of oil is six or seven times the price of coal, because of the savings and advantages obtained with these engines.

For marine purposes in general, oil fuel has many and great advantages over coal. Its heat value per pound is 50 per cent greater than that of good coal, so that even with steamships only two thirds the weight of fuel is required. It can be stored in the double bottom and in other remote parts of the ship. It is self-trimming. It can be put on board in much less time and with entire absence of dirt and dust—with steam plant fewer or smaller boilers are required. Stokers and trimmers are not wanted. It is not liable to spontaneous combustion, and there are no ashes to be got rid of.

It has been estimated that if all the power-propelled ships in existence were driven by Diesel engines of the present realized efficiency, the amount of fuel required per annum would be about 25 million tons. In Germany, owing to a heavy import duty on oil, a great deal of attention has been devoted to the manufacture of oil from coal tar, and practically all the heavy oil engines in Germany are run on tar oil, of which the output during this year will probably amount to about one million tons. This is probably about five times as much as would be required for all the ships of her navy if these were propelled by Diesel engines; and as a Diesel engined ship can carry sufficient oil to enable her to go to any part of the world, fight her battles, and return home without taking in any fresh supplies, the relative advantages which we at present possess, due to our coaling stations, would vanish if she were to adopt Diesel engines for the propulsion of her ships of war. Possibly the realization of this great increase of power has had something to do with the enormous expenditure of energy and money on researches and other experimental work in connection with Diesel engines in Germany.

We, unfortunately, have no natural supply of oil in this country, and if we are to continue to use coal for marine propulsion we must devote ourselves to the evolution of a suitable gas producer. Coal, however, is not a source of heat energy only, but it can be made the source of valuable products, such as sulphate of ammonia and tar. The amount of tar at present produced in this country is sufficient to provide much of the oil which will be required for marine purposes, but we may soon find it more profitable to convert coal into coke or coalite and gas, than to burn raw coal for domestic and power purposes.

Birds and Weather*

By A. Landsborough Thomson

THE difficult question of the influence of meteorological conditions on the phenomena of bird migration has fortunately been very thoroughly studied as regards the British area, but we are none the less glad to welcome the recent labors of Dr. Defant on this subject. Dr. Defant as a meteorologist has submitted to a critical examination the data collected some years ago regarding the spring arrival in Austria of some thirty species of birds. He has selected four species for special treatment, and the data cover a period of seven seasons (1897-1903). The published weather reports have supplied all the necessary meteorological data for the corresponding periods.

At the outset of his paper Dr. Defant points out that, while all meteorological factors must be taken into account, the relation of all other conditions to that of atmospheric pressure renders possible a concentrated attention on the latter. A comparison of the ornithological data with the temperature records gave a purely negative result, no direct relation being discoverable. Dr. Defant also rightly insists on the importance of considering the weather of the whole of southern Europe, the conditions prevailing in the actual area of arrival being obviously less important than those in the regions immediately to the south through which the migrants must pass.

The spring immigration of the starling and the lark are treated together, these species showing a detailed similarity in this aspect of their seasonable movements. Tables are given showing that there is an annual variation both in the earliest date of arrival and in the duration of the influx. The period of heavy immigration usually lasts about eight days and the average date of maximum arrival for the seven years was February 23rd, while the average dates for particular years varied from February 12th to March 3rd.

With the partial exception of one year out of the seven it was found that the periods of maximum immigration coincided with periods of low atmospheric pressure in the west and northwest of Europe, and higher pressure in the south, southeast, or east. These conditions give southerly or southeasterly winds in Austria and the countries immediately to the south, and usually rising temperatures. The immigration was all the greater when these favorable conditions had been immediately preceded by a prevalence of high pressure in the north and northwest (or northeast) and low pressure in the east or southeast; such conditions usually entail low temperatures and northerly or northwesterly winds.

Dr. Defant then considers the average daily pressure for the three regions into which he divides southern Europe. These are A = western Asia Minor, the Balkan Peninsula, the Adriatic Sea, and southern Italy; B = the remaining greater part of Italy, the western Mediterranean, and northern Africa; and C = Spain and Portugal. The last named region is soon shown to be irrelevant, and Dr. Defant's second conclusion results from a comparison between A and B. He finds that strong immigration in Austria occurred when the pressure in these regions was relatively higher than on the days immediately before and after and when the pressure in A was higher than in B. The east to west pressure gradient thus formed, when coupled with the effect of the earth's rotation, produces the southeasterly winds characteristic of the type of weather already described as favorable to migration.

The cuckoo and the house martin are then treated in like manner (not jointly as in the previous case, but simultaneously to economize space in tables and graphs). The same two conclusions are arrived at for these immigrations occurring much later in the season than that of the starling and the lark. A second type of weather was also found favorable in the case of the cuckoo, namely, extended high pressure over the whole of central and southern Europe, usually with weak easterly or northeasterly winds. In seasons in which the strongest immigration occurred under such conditions the period of the chief movement was protracted to about nineteen (instead of about nine) days.

Dr. Defant has clearly proved that a certain type of weather is peculiarly favorable for the spring immigration of Austrian birds.

His further speculations are, however, open to serious criticism. He believes that the important factor in this type of weather is the wind and that birds prefer to fly with it behind them. His reasons as to *why* birds should do so seem to us to be wholly beside the point, and as the much more comprehensive results already obtained in this country are entirely opposed to Dr. Defant's theory, we cannot accept it, however temptingly obvious it may seem, on such very slender grounds.

The alternative theory is that "the winds and the performance, or non-performance of the migratory movements are the effects of a common cause, namely, the particular type of weather prevailing at the time, which may be favorable or unfavorable for the flight of birds. . . ." (Eagle Clarke, "Studies in Bird Migration," 1912, p. 173.)

In the British area there are certain types of weather favorable, respectively, for migration between the British Isles and northern Europe, between the British Isles and Iceland, and between the British Isles and southwestern Europe. The winds accompanying these types of weather *may or may not* be in the same direction as the movements concerned. Furthermore, the same types of weather favor these movements both in autumn and spring, the direction of flight being reversed while the prevailing winds remain the same.

In Dr. Defant's simpler case it so happens that the favorable type of weather he has discovered produces a wind in the same direction as that of immigration from the Balkin Peninsula (his region "A") to Austria; but the immigration from the southwest ("B") probably forms a large part of the movements which were the subject of investigation. It is unfortunate that only the spring migrations have been dealt with. Should the same type of weather with its accompanying winds prove to be favorable to the autumn emigration (as in the case of the British movements), Dr. Defant's theory would be quite untenable.

In the meantime Dr. Defant's selection of wind as the important factor is purely speculative, and his view entails an entirely different relation between birds and weather in Austria from that existing in the British Isles. While rejecting his theory of the importance of wind as unproven and improbable, we feel grateful for the new facts which he has added to our knowledge of bird migration by his most laborious and thorough research.

* "Der Einfluss des Wetters auf die Ankunftszeiten der Zugvögel im Frühling." By Dr. A. Defant, Vienna. Reproduced from *Nature*.

Balancing Internal Combustion Engines

IN a paper read before the Institute of Automobile Engineers, F. W. Lanchester considered this important subject at considerable length, and includes a short description of his anti-vibrator and his crankshaft vibration damper. The function of the "anti-vibrator" is to supply a countervailing movement of mass of the same periodicity, and of sufficient magnitude to neutralize the unbalanced octave component of the piston motion. To this end, two reverse rotating balance weights are employed, or two pairs of such weights, each of which supplies a vertical component sufficient to quench one half of the unbalanced piston component, the horizontal component of motion of the rotating masses being arranged to neutralize one another after the style of the balance weights fitted to the crankshaft of the old 12 horse-power Lanchester engine. This device can be employed simultaneously for the correction of the octave vibration and for the elimination of vibration due to piston inertia.

The solution to the torsional vibration trouble with crankshafts has been found by the author to consist in a vibration damper attached to the tail or free end of the crankshaft. This damper in the form fitted by the Daimler Company, comprises a small flywheel mounted to rotate freely on bearings, and in driving connection with the crankshaft through a multi-disk clutch arranged in an oil bath, ordinary viscous cylinder oil being used as lubrication. The damper, so fitted, does not impede rotational motion in the smallest degree—it is carried round with the crankshaft without offering resistance—but it forms an immediate and considerable resistance to anything in the nature of angular or torsional vibration. Since the introduction of this damper, it is stated that all difficulty previously experienced in the driving of valve gear from the tail end of the crankshaft has disappeared.

The Experimental Plotting of Electro-Static Fields

A Simple System Useful in Designing High Tension Insulators

By S. H. Querbocker and Morgan Parsons

No doubt some who read this article will at one time or another have plotted electro-magnetic fields by sprinkling iron filings on a sheet of paper held over a magnet. But how many have plotted the electro-static field between two charged bodies? With the increasing use of high voltages interest in electro-static effects has revived, and methods of plotting these fields have become of interest.

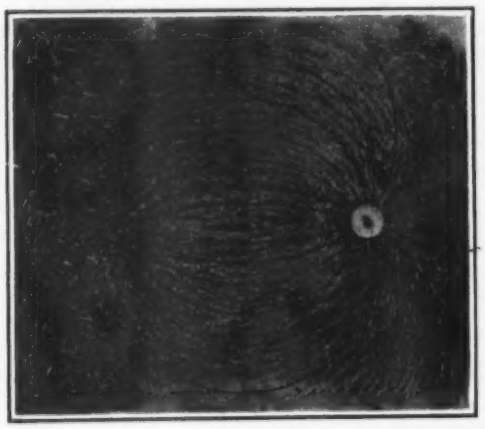


Fig. 3.—Field produced between two 2-centimeter disks placed 15 centimeters apart. The full lines show a field calculated from theory.

One of these methods is comparatively simple and, in outline, is as follows: A thoroughly dried, fine grained, wooden plate is secured and held in a suitable insulating stand, as shown in figure one. The base of this holder is twenty-four by twenty-four inches; the glass tubes are also two feet long; small wooden buttons are set in the top of the tubes to support the corners of the plate; and the two clamps on the back tubes are used to hold the supply leads. With such an arrangement as this any size plate up to 20 by 20 inches may be used. Next a sheet of loose texture paper, such as is used by newspapers, is fastened on the wooden plate with thumb tacks. Terminals of the desired shape are then cut from tinfoil, pasted on the paper, and wired to a source of high voltage through a suitable switching gear. Powdered mica is then sprinkled over the paper in a thin uniform layer. It will not be difficult to do this if a flour shaker is used, and the sprinkling done from well above the paper. Next the voltage is switched on, and the plate tapped gently with a long rod of glass or other insulating material; the operator standing on a non-conducting platform. As the tapping is done the mica will be seen to form into the lines of the field. No one, of course, should be near the apparatus when the voltage is switched on, for in most cases at least 5,000 volts will be necessary to form the field. Though there are several other methods the one outlined above is simple of performance and may be made to produce good results after comparatively little practice.

Sheet mica may be powdered by using a milling cutter, and various sizes produced by changing the speed of cutting. For plates eight by twelve mica that has passed through a twenty mesh sieve and over an eighty mesh one will be found very good. The best results will be obtained on a dry day working with mica that is also thoroughly dried.

If it is desired to make permanent records blueprint paper may be substituted for the loose texture paper mentioned above, and then printed while the mica dust field is still on it. Or a still better modification is to use black paper paraffined rather heavily by dipping. Then proceed as before until the field is formed. Next melt the paraffin sufficiently to set the mica, but not enough to move it from its position. To do this an oven may be used or a lamp bank will serve the purpose. A coat of shellac, sprayed on when the paraffin is cool, will aid in preserving the plate. This latter method was the way the fields were made from which the photographs were taken. The fields will be found to show up very nicely on the black paper. Fig. 2 shows the general layout of the apparatus.

The photographs reproduced here are all from negatives that have not been retouched. Fig. 3 shows the field between two 2-centimeter disks with 15 centimeters between centers. Superimposed on this field is one calculated according to theory, for point sources. The potential difference was 10,000 volts. Allowing for the discrepancy due to the fact that the disks are not exactly point sources, the fields may be said to be alike. Fig. 4 illustrates a needle point at the center of the arc of a circle, and was subject to about 5,000 volts. From this may be seen the well-known fact, that a field is stronger at a point than over a large area.

Fig. 1.—Stand used for plotting electro-static field.

Fig. 4.—Needle point at center of arc of a circle, showing that a field is stronger at a point than over a large area.

It also shows that this method will indicate the intensity of a field as well as its direction. In Fig. 5 a strip of tinfoil, with sides that follow two equipotential surfaces, is interposed between the two circular disks. This arrangement gives a better distribution of the field than if the sides of the strip had been parallel.

The fields obtained in this way are of value in designing high tension insulators, as well as being interesting theoretically. For insulator design work these fields show the distribution on a plane passed through the axis of the insulator. From the standpoint of theory, the best possible shape for an insulator to follow is that of one of the flow lines of the field; practice, however, modifies these shapes.

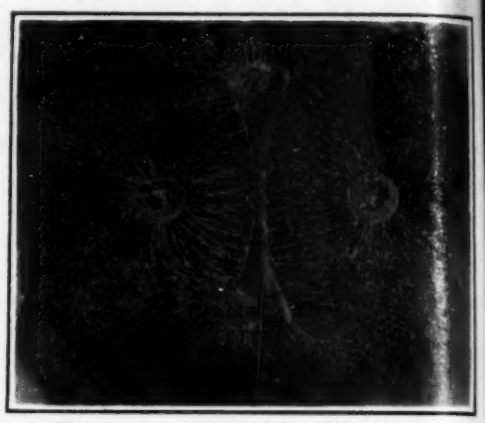


Fig. 5.—An equipotential surface between two disks.

The work from which the above results were obtained was carried on in the alternating current laboratory of the University of Pennsylvania Electrical Engineering Department.

International Volts

In accordance with the decisions of the London conference the silver voltameter is to be used to measure the international ampere, and this in connection with the international ohm may be used to measure international volts. On the other hand, a standard cell whose voltage is expressed in terms of the mean Weston normal cell taken as 1.0183 volts at 20 deg. Cent., is now the recognized method of measuring international volts in accordance with the recommendation of the International Committee on Electrical Units and Standards. The difference between the two measurements will be the same as the difference between the round value 1.0183 volts recommended by the International Committee, and adopted for use by the several countries, and the more exact figure expressing precisely the value found by means of the silver voltameter and a standard resistance, assuming that the errors of measurement are negligible. From a long series of determinations with the voltameter we believe that this difference is about 3 parts in 100,000.

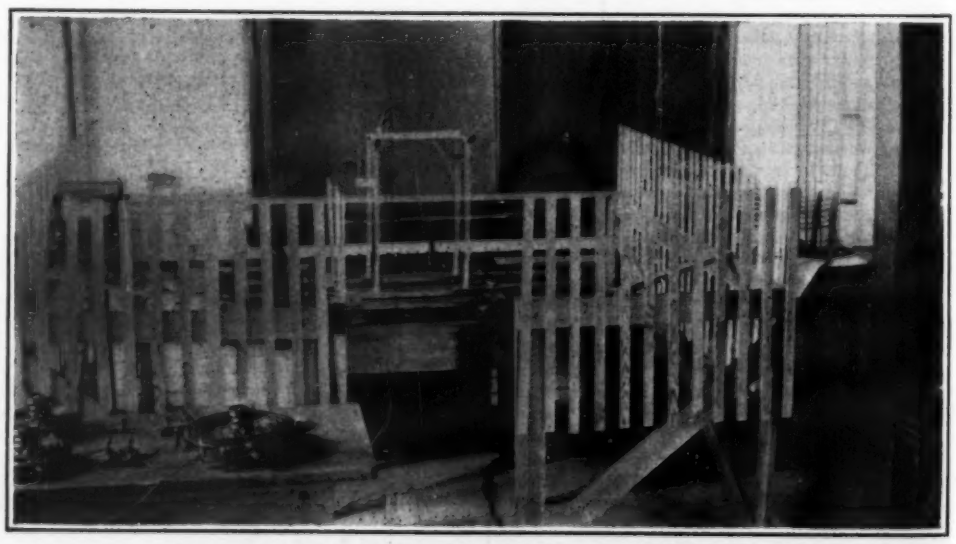


Fig. 2.—General arrangement of apparatus for plotting electro-static field. Note protecting fence around the stand.

Fig. 2.—Torpedo head shop. These cones enclose the explosive, and are furnished with percussion needles.

Fig. 3.—Torpedoes ready for delivery. The explosive heads are not affixed until just before they are launched.

The Automobile Torpedo*

The History of the Development of a Remarkable Invention

For a long time the cannon was the main fighting arm for ships. During the last quarter of the last century the struggle for supremacy between it and increasing efficiency in armor was the reason for such improvement that it is to-day at the highest point of perfection it is likely to attain.

But about 1870 there appeared another naval weapon, the self-propelling torpedo, invented and constructed by Whitehead. This showed its potential power during the war between Chile and Peru (1877), but nevertheless, it was only a weak weapon. The diameter of the early torpedo was 13 inches, its weight not far from 400 pounds, and it carried a charge of explosives of only 35 pounds. Its striking distance was limited to 200 meters (656 feet) and its greatest speed in the water was about 8 knots.

The genial inventor of this weapon was born at Bolton-le-Moors, England, January 3rd, 1823. At fourteen he quit school to become an apprentice in a mill in Manchester, where his uncle was superintendent. At twenty-one he was a draughtsman at Marseilles, and three years later he went to Milan, where his occupation was with silk looms. Here he patented a number of important inventions in machinery for weaving. He was next director of the Stabilimento Tecnico, at Trieste, and in 1858 he helped establish at Fiume, not far distant, a marine engineering works which prospered. Of this he became proprietor in 1872, and changed it into a factory for the construction of torpedoes.

The story of the evolution of the Whitehead torpedo is this: In 1860 Capt. Luppis of the Austrian navy conceived the idea of a vessel for coast defense, dirigible from a distance and carrying a charge which when the boat struck a ship or an obstacle would be exploded. In 1864 Whitehead and Luppis associated themselves for the purpose of developing the idea. It was very soon found to be impracticable, but Whitehead thought that the dirigible boat might be changed into a submarine projectile capable of making its own way when launched into the water. The first torpedo was constructed in October, 1866, and despite numerous and important improvements, it was considered even up to the opening of the Russo-Japanese war a weapon of uncertain value. Since that date, however, the opinion of experts has been changed. The first experiments showed that the essential quality to develop was speed, and the efforts were largely along that line for a time. Then on account of the continually greater resistances of the armor of ships it was necessary to increase the explosive charge. Then the development of rapid-fire guns made it more difficult for the torpedo boats to approach their adversaries and greater radius of action was necessary in the torpedoes themselves. The different demands led to gradual increase in the caliber of the projectile, but here the question of weight came as a determining factor. It is necessary not to exceed the weight or dimensions that can easily be handled on shipboard. Next there was the use of compressed air for motive power. It has been through the combination of all these factors by dint of an enormous amount of ingenious invention and adaptation that the modern torpedo has been possible.

The following specifications, compiled from various statements will serve to outline the development of the torpedo.

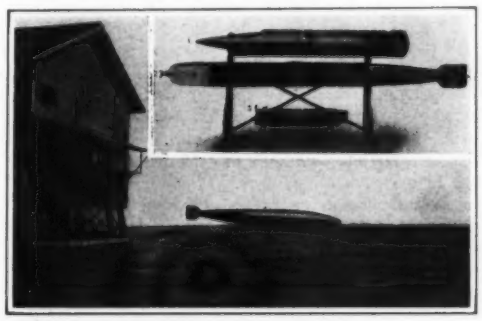


Fig. 1.—Launching trial torpedo.
Insert 1, the first torpedo; 2, torpedo of to-day, 3, dirigible boat of Lappis.

Model of.	Diameter. mm.	Weight. kg.	Speed. knots.	Range. meters.	Charge. kg.
1868 ..	331	180	6-8	200	18
1889 ..	381	432	22	1,500	75
1892 ..	450	...	25	2,000	94
1906 ..	450	650	40	3,000	100
1912 ..	450-533	900	45-48	6,000	136

The model of 1906 was the turning place which made the torpedo a real rival of the cannon. The speed was raised to 40 knots, and the distance possible to 3,000 meters (more than a mile and three quarters). The caliber remained constant, but the projectile was lengthened and new machinery introduced which increased the weight. The type of 1912 shows still further advances, and a range of nearly four miles, but the weight limits its use to vessels of larger, modern dimensions.

Everywhere skilled men have been working for the perfection of the torpedo, and the processes of improvement are everywhere evident, notably in the machinery. By employing larger reservoirs of compressed air the range of its action has increased even up to 10,000 meters. On the other hand it is necessary to travel this distance with such speed that the vessel against which it is aimed cannot run away or maneuver so as to avoid it. One of the processes tending to increased efficiency is the heating of the air. This has been an important step, carrying the solution to grave difficulties, among them the problem of lubrication. Compressed air when liberated is an excellent refrigerant, and it has been found that the temperature of the exhaust is frequently below zero Cent. Such cold produces annoying troubles in freezing the lubricants in a machine which must employ them everywhere, and the high temperature of the air modifies this difficulty.

Various systems are employed for heating the air for torpedo engines. The usual method employed is by burning alcohol either within the air reservoir or in the pipes leading to the motors. The illustration (Fig. 4) shows the device (*SH*) within the tank of compressed air. The advantage of heating the air is shown by the following table of comparison. The speeds are given for different distances from the firing station, the torpedoes actuated by heated air not only attaining a higher early velocity (almost one quarter greater), but maintaining a higher percentage of it through a long run (65 per cent against 57).

Distance.	Speed with cold air.	Speed with heated air.
1,000 meters	35 knots	43 knots
1,500 meters	30 knots	40 knots
2,000 meters	28-25 knots	38 knots
3,000 meters	25-24 knots	32 knots
4,000 meters	18-20 knots	28 knots

Then by another very ingenious device it is possible to give the self-propelling torpedo a trajectory that is effectively rectilinear by furnishing it with a gyroscope governing the rudders. It is possible in this way to keep the axis of the torpedo to the direction given it on the start. The apparatus was planned by Obry of the Whitehead shops at Fiume, and is generally known by the name of the inventor. At first the motive power to keep the gyroscope in motion was a spring, but this proving irregular a little motor run by compressed air is now used. The original model of Obry had a minute dynamo.

Theoretically, it is merely necessary to aim the torpedo correctly to have it strike the target, but here there are practical difficulties, for both sender and receiver may be in motion, and there is besides the uncertainty that every hunter feels in the presence of game.

A very real improvement in the modern automobile torpedo is that the quantity of explosives has constantly been increased. From the earliest model with about 33 pounds to those in use to-day, which have as much as 300 pounds of gun-cotton, the step is a long one, and the present missile is capable of causing great destruction in the hulls of even the best protected vessels.

It is interesting to note the different lines of development in the various powers of the world with reference to the torpedo.

In France the modifications have led to a type of 450

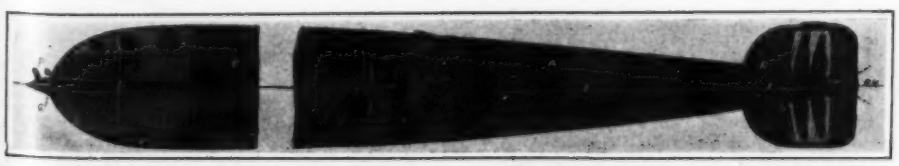


Fig. 4.—Section of Bliss-Leavitt torpedo.

P, percussion needle; *G*, safety pin; *C*, explosive; *D*, priming; *B*, compressed air tank; *K*, water valve; *H*, pendulum; *M*, motors; *SH*, air heater; *O*, plunge-motor controlling the depth of immersion; *V*, gyroscope; *T*, gyroscope spring; *GH*, plunge rudders; *FG*, rudder controls; *E*, shaft; *I*, propellers. The steering rudders are the little dark squares in the forward expansion of the tail.

* Compiled from *La Nature* and *La Science et la Vie.*

millimeters with a charge of 108 kilogrammes of gun-cotton, the explosive force of which is four times that of gun-powder. The weight of the projectile is 2,600 pounds; the range, 9,000 meters, the early velocity 42 knots, which is maintained up to 2,000 meters, with the final velocity not less than 28 knots. The price of such a projectile is about $4,000. The new French armored ships are furnished with six torpedo tubes below the water-line and protected against direct shots, while the submarines now carry eight tubes.

England uses torpedoes of 533 millimeters caliber of the Armstrong & Hardcastle models, with an early speed of 45 knots and ability to maintain high speed, and the charge is 130 kilogrammes of explosive.

Germany places on board its armored ships a torpedo of 530 millimeters with 128 kilogrammes of explosive, while the cruisers and torpedo boats use another model of 500 millimeters, but with the shorter range of 4,000 meters. Studies have been made with torpedoes of 600 millimeters with great speed and range.

Russia is the only power besides France that has kept to the model of 450 millimeters, but with a heavier charge, 125 kilogrammes. The range of the Whiteheads it uses is greater than 6,000 meters.

In the United States the model adopted is the Bliss-Leavitt (see illustration) of 533 millimeters diameter with 128 kilogrammes charge, capable of making 36 knots at 1,000 meters and 30 knots at 4,000 meters. Experiments have been made with others of the projectiles with effective distances up to 9,500 meters.

As to modern tactics with these terrible weapons, it consists no longer of isolated shots, but in volley fires. Such a discharge of a number of torpedoes against a line of ships is considered as sure of results. The torpedo boats under such circumstances will have some advantages, for after the first phases of a naval combat a certain amount of confusion is likely to be produced by some of the vessels showing signs of weakness, and then they can charge the fleet in a body. This may take them to within 2,000 or 3,000 meters of the enemy, and without doubt they can from there send out torpedoes that will be pretty certain to hit.

It is generally estimated that at 4,000 meters 30 per cent of the torpedoes will be effective. If this were only ten per cent, and out of 40 projectiles 4 explode and put out of the battle two or three vessels, the attacking fleet will have achieved enormous results.

Torpedoes have the general form of a cigar, being about 5 to 6 meters in length with a diameter of about 450 millimeters. The body is of steel, and consists of four sections firmly screwed together. The head, about one eighth of the whole length, is conical in form, and within it is the explosive furnished with the percussion apparatus, which, when the projectile strikes an obstacle, ignites the priming and causes the explosion. Behind this is the second section with the air reservoir, a steel cylinder containing compressed air for the motors and machinery. The third section may be called the engine room, where there are the various devices for propulsion, steering—both laterally and vertically—etc., and behind this a combination of shaft-room and rudder runs. There are two propeller shafts, one within the other, each with its own screw. The propellors are in a kind of cage of square frames, the pattern of which varies in the different torpedoes, which furnish bearings for the propellers and supports for the rudders.

The Atlas of Finland*

A Model Geographical Work of a Little Known but Interesting Country

Review by Gustave Regelsperger

[*The beautiful work, of which the French edition bears the title "Atlas de Finlande, 1910," was published at Helsingfors, in 1911, by the Society of Geography of Finland. It is a statistical atlas of very wide scope, its nearest American parallel being the "Statistical Atlas of the United States," which our Bureau of the Census issues periodically, and of which a new edition will probably appear during the present autumn. There are, however, important differences between these two works, as to scope and treatment. The Finnish atlas, with its two accompanying volumes of text, is, in fact, unique as a complete compendium of the geography of a country, using the term "geography" in its broadest sense. In scholarship and workmanship it is hardly surpassed in the whole range of geographical literature.*—EDITOR.]

LYING between Sweden and Russia, Finland pertains geographically and geologically to the former. In the north it is in no way distinguished from Sweden, whose dense forests are continued across the border. In the south it consists of a lacustrine plateau, resembling that of Småland, which, on the other side of the Baltic, forms the southern extremity of Sweden; both are covered by a complicated network of lakes and interconnecting water-courses. In spite of its affinities with Sweden, however, Finland well deserves to be studied as a separate geographical unit, in view of its pronounced topographic features, its position between Sweden and Russia, and its outline, in virtue of which it forms a large peninsula between the Gulf of Bothnia on the one hand and the Gulf of Finland, prolonged by Lake Ladoga, on the other. Finland may, in fact, be considered as forming in certain respects a transition between the two countries which border it. It lacks the high mountains of Sweden, its relief not surpassing that of the eastern coast of the Scandinavian peninsula, so that we may regard it as a step leading from the high terraces of Sweden to the marshes of the Baltic provinces of Russia and the plains stretching thence to the Ural and the Caucasus.

However, the individuality of Finland as a country is due in even larger measure to its population; the Finns, who are greatly in the majority, being a totally different race from those which inhabit the neighboring countries. On account of their position, the Finns have necessarily been subject to attacks and invasions on the part of the Swedes and the Russians, and the history of Finland is made up chiefly of these struggles. Though generally preserving more or less autonomy, Finland has never been entirely independent. For centuries it was ruled by Sweden, and it is now a part of Russia. Yet, as the home of the Finnish people, with only a small Swedish element, and a still smaller Russian, it has withstood the efforts of Russia to assimilate it to herself, and preserves unmistakably the germs of an independent national existence. Impelled on the one hand by the patriotic idea of making the Finnish people better acquainted with their country and with themselves, and on the other hand by an ambition to contribute to the general fund of geographical knowledge, the Society of Geography of Finland determined to present a detailed record of both the physical and the human geography of this interesting land, and in the fulfillment of this determination has produced a work of the highest rank.

The first edition of the atlas appeared in 1899, and was the development of material presented by the society at the Sixth International Geographical Congress, held in London in 1895. The edition now under review bears imprint 1911. The committee responsible for its production had at its head Colonel and ex-Governor Max Alfthan, who was a member of the committee which compiled the earlier edition, and three other members of the same committee, viz., J. A. Palmén, secretary of the society; Prof. J. J. Sederholm, director of the Geological Commission; and E. G. Palmén, professor of Scandinavian and Finnish history at the University of Helsingfors; also two new members, viz., Mr. Onni Olila, chief of the Cartographic Bureau of the government survey; and Dr. K. R. von Willebrand, chief engineer in the Department of Roads and Bridges. As compared with the 32 sheets of the first edition, the second contains 55; while the text, which also contains numerous charts, illustrations, and graphs, has more than tripled. The atlas volume is issued in a single edition, with titles and explanations in Finnish, Swedish and French; while of the two text volumes there is a separate edition for each of these three languages. The French translation is by Prof. J. Poirot, of Helsingfors. The atlas is divided into two parts, to each of which corresponds one of the volumes of text; the first devoted to the physical geography of the country, the second to its human aspects.

I. PHYSICAL GEOGRAPHY.

In his exposition of Chart I—the general map of Finland—Mr. Olila traces the history of Finnish cartography. The earliest charts date from the fifteenth and sixteenth centuries. That of Olaus Magnus (1539) is noted as having been the first to give a tolerably correct idea of the configuration of the country as a whole, and its position with respect to the adjoining countries. The earliest productions of serious merit, however, appeared in the fore-part of the seventeenth century, and were issued under the auspices of Charles IX., of Sweden. One by Andreas Bureus (1626), reproduced in the present atlas, was a remarkable work for its time, though it shows a non-existent chain of mountains running through the middle of the country. In the eighteenth century new surveys were made, in connection with the division of lands and the fixing of taxes, and these led to the excellent series of charts published from 1797 to 1807 under the auspices of Baron Hermelin. Parish charts on a uniform scale (1 to 20,000) were issued by the government survey department between 1840 and 1850, as well as charts of districts, based upon these, on a scale of 1 to 100,000. A general map of Finland in 30 sheets, based on a network of points fixed astronomically, was issued by the government in 1863–72. Only two extensive geodetic surveys were, however, made in Finland during the nineteenth century; viz., that of the Russo-Scandinavian meridian, extending from the mouth of the Danube to the Arctic Ocean, executed from 1816 to 1855, which crossed Finland; and the Baltic triangulation made from 1828 to 1838 by the Russian authorities, under the direction of General Schubert.

The general chart published in the atlas on a scale of 1 to 2,000,000 was drawn up by the society itself, with the use of all available material, and is based upon about 500 accurately determined positions. The same chart, with or without reduction, is used as a base-map for the other charts of the atlas.

Chart I shows the political subdivisions and the hydrography, but not the relief. Chart II is hypsometric. From this chart it is evident that no part of Finland is truly mountainous except the extreme northwest corner, which projects deep into the Scandinavian peninsula, to which geographically it belongs. In fact, the culminating point of Finland, Halditschokko, which attains only 4,440 feet, lies on the frontier. Aside from this small northwestern region, Finland is a very hilly but not a mountainous country. Seen from a balloon it would appear remarkably flat, but it really comprises innumerable small irregularities. Over the greater part of its surface the altitude varies between 300 and 1,300 feet above sea-level.

Throughout Finland there is an extraordinary abundance of water. Including the Finnish portion of Lake Ladoga, 11.73 per cent of the entire surface of the country is made up of lakes and streams. In the south, especially, the lakes are innumerable, while bogs and marshes are found everywhere. Southern Finland, which presents the most characteristic landscapes of the country, has been called "the land of a thousand lakes"—but "tens of thousands" would be a more accurate description. Chart 12 of the atlas, showing this lacustrine plateau, presents a truly fantastic appearance. This chart alone includes 9,600 lakes; while a chart of all Finland, on a scale of 1 to 400,000, includes no less than 35,500. The surface of the country may be compared to a sponge full of water which has been stretched out from southeast to northwest, as nearly all the water-courses and the majority of the lakes trend in that direction.

The shores of these lakes are extremely cut up with bays and inlets, and their bottoms are extremely uneven, and rarely of much depth. Chains of lakes are very common. The streams which drain the various lake basins are interspersed with rapids, generally of moderate gradient. Chart 14 shows the location of these rapids, and the water-power which each is capable of furnishing at low stage.

The peculiar hydrography of Finland is explained by its geological history. The atlas treats the geology of the country historically. Chart 3 shows the prequaternary rocks, and Chart 4 the quaternary deposits; while several additional charts, on a smaller scale, deal with the history of the whole Fenno-Scandinavian region, showing the progress and effects of quaternary glaciation, and the fracture lines due to violent earthquakes in the tertiary period.

The soil of Finland consists chiefly of hard crystalline rocks—granites, gneiss and schistes—formed at a very early period. A coarse red granite known as *rapakivi* is characteristic of the country. The commonest sedimentary rocks of this region are pre-Cambrian. These earlier formations show marked folding, the folds running from southeast to northwest, and this direction was subsequently followed by the glaciers. Hence the curious appearance of the lacustrine plateau, which looks as if an immense harrow had been drawn across it. Before the glacial period, however, the country had been fissured in all directions by violent upheavals and subsidences. The wonderful modern network of lakes is, therefore, due to the same combination of causes which produced the similar lacustrine landscapes of Sweden, Russian Karelia and Canada.

The same process which produced the Finnish lakes gave rise to the remarkable Aland and Abo archipelago, lying off the southwest extremity of the country. This consists of numerous large islands and a myriad of islets, rocks and shoals, spread like grains of dust over the chart (No. 10). It is aptly described by Prof. Sederholm as a

* Abstracted from *Revue Générale des Sciences.*

submerged landscape of lakes, i. e., the same landscape that prevails over southern Finland extended out into the sea.

An important series of charts deals with the hydrography of the adjacent seas, viz., the Gulf of Bothnia and the Gulf of Finland, showing the limits of ice, temperatures at various depths and at various seasons; maximum and minimum temperature at the bottom, salinity, oxygen content, surface currents, tides, color and transparence. There are also bathymetric charts of the Gulf of Finland and Lake Ladoga, showing both these bodies of water to be relatively shallow.

Four plates of the atlas (Nos. 16–19) consist of meteorological charts. The accompanying text, by Dr. O. V. Johannson, of the Central Meteorological Institute, includes a brief history of meteorological observations in Finland, dating back to the seventeenth century. The charts include, in addition to isotherms, isobars, isohyets, wind-roses, and other data of usual character, a chart showing the average date of first snowfall; charts of the depth of snow-cover in each winter month; and a chart of the depth of snow on March 25th, 1899, after a period of excessive snowfall. There is also a chart showing the average date on which the ice breaks up in the spring; while four charts relate to thunderstorms. Owing to the prevalence of west and southwest winds—i. e., moist, mild winds from the Atlantic—and to its moderate altitude, Finland has not a rigorous climate. Cloudiness is excessive, but the rainfall comparatively light.

Several charts dealing with the flora and fauna conclude the part of the atlas devoted to physical geography. Finland is well covered with forests, but the true forest region is the northern half, which belongs to the wooded zone that characterizes the whole of northern Russia. The state forests (shown by a separate chart) are almost all in this zone. The greater part of the country lies within the great northern belt of conifers; but toward the north this is succeeded by a zone of birch, while in the extreme south Finland enters the oak region of central Europe.

In the treatment of the flora, the country is divided into 31 botanical provinces. The number of vascular species, indigenous or naturalized, is shown for each province, the total being about 2,182. Among these are 21 species of trees. The limits of cultivated plants of various species are shown on two charts; one devoted to the cereals; the other to potatoes, cabbage, clover, textiles, etc.

In the indigenous fauna of Finland there are recognized 61 species of fishes, 5 batrachians, 6 reptiles, 232 birds, and 54 mammals. The limits of certain species are shown by charts. It is noted that a part of the fauna is threatened with extinction by the advance of human settlement. This is especially brought out by charts showing the limits within which bears were shot during successive periods of years, and the relative number of lynxes shot in recent and in former times.

Other charts and their accompanying text give detailed information regarding fishes and fisheries, of both the seas and the inland waters. The Baltic, on account of its low salinity, is not rich in true marine fishes. Salt water and fresh water species are curiously mingled. The most abundant and economically important marine species is the Baltic herring (*Clupea*). The first volume of text concludes with a notice of the marine plankton, by Prof. Levander.

II. HUMAN GEOGRAPHY.

The studies of human geography embodied in the atlas are fully as important as those relating to physical geography, and are the fruit of a truly enormous amount of statistical material.

Trustworthy demographic data date back to 1750, at which period statistics of population began to be collected on a uniform plan by the clergy, under the auspices of the Academy of Sciences. The atlas includes graphs showing the progress of such data down to 1907, as well as numerous charts presenting conditions at the present time, or for other specified periods. The growth of population during 157 years has been fairly uniform, except that certain definite calamities—wars, epidemics, and famines—have left their traces conspicuously in the curves. During the period in question the population increased from 534,065 to 3,012,849. The chart showing the present density of population in each parish brings out the striking contrast between the well-populated coast regions and the very sparsely inhabited regions of the north. An even more striking chart (No. 26) shows how the population tends to cluster along the water-courses, around the lakes, and on the islands of the Abo Archipelago.

One of the most instructive charts, with its accompanying text, presents statistics of emigration (most of which is to the United States). The mean annual number of emigrants per 10,000 inhabitants, during the period 1893–1907, is shown for each parish in the southern half of the country, and is seen to have been far greatest from the Österbotten coast region; especially from the governments of Uleaborg and Vasa. The total annual emigration during the above period has varied from 10,000 to 20,000. Unhappily for the country, three quarters of the emigrants are drawn from the agricultural population. Prior to 1880, emigration was very small.

As to the races in Finland, the Finns constitute 87 per cent of the population, and the Swedes barely 13 per cent. The latter are found chiefly in Aland and the adjacent archipelago, and in certain other littoral regions. In 1900, the language spoken by 2,352,990 persons was Finnish; while 349,733 spoke Swedish, 5,939 Russian, and 1,925 German. Far in the north is a small population of Lapps (1,515 in 1910). Gypsies are estimated to number 1,551. It is interesting to note the encroachments of the Finnish population upon regions formerly occupied by Swedes, as shown by the survival of Swedish place-names far in the interior, where the inhabitants are now all Finns.

The sanitary condition of the people is shown in considerable detail, with charts representing the distribution of specified diseases and defects. Pulmonary consumption causes great ravages in Finland, more especially along the western coast.

The economic life of the country is shown in a long series of striking and instructive charts, to which correspond the greater part of the memoirs in the second volume of text. These are so various that it is difficult to summarize them in a brief review. Two series of charts under this head deal with agriculture and manufactures, respectively. A number of ingeniously constructed graphs present a wealth of information concerning the foreign commerce of the country, and its fluctuations. Cereals and woven fabrics are the commonest objects of importation, while by far the most important exports are the products of the forests. The export trade in butter ranks second. Chart No. 40 shows the measures that have been taken to facilitate navigation in the difficult waters of the Gulfs of Bothnia and Finland, with their innumerable islands and intricate channels. This chart indicates the locations, kinds, and ranges of all the lighthouses on these shores, whether Finnish, Swedish, or Russian, as well as the lights on the large lakes; also the extent of the hydrographic surveys that have been carried out by the Finnish and the Russian authorities.

The inland communications of the country, by land and water, are shown in great detail. Finland is not only well supplied with roads (and in the south with railways), but it also possesses a system of water communications without rival in Europe. It has 4,060 miles of telegraph lines, and 58,400 of telephone.

The economic portion of the atlas concludes with charts relating to savings banks, the co-operative movement, and insurance. Then come charts dealing with political geography and one showing the distribution of schools and the school attendance. From these modern themes the atlas suddenly reverts to prehistoric times, with some admirable charts devoted to archæology. It is interesting to note that the remains of the stone age indicate a distribution of population in that period corresponding rather closely to that of to-day.

Last of all come charts, on a scale of 1 to 30,000, of the 38 principal towns of Finland. These range in population from Helsingfors, with 137,346 inhabitants, to Nadendal, with 903. In the text volume, the history of these towns is given in detail.

Though only a hasty sketch, the foregoing review will perhaps suffice to give an idea of the extent and variety of the material embraced in the Atlas of Finland and the two volumes of text that accompany it. The Society of Geography of Finland has furnished a striking example of what should be understood as comprising the geographical study of a country. From environing physical conditions spring, necessarily, the development and characteristics of a people; there is no physical geography without a human geography, nor can one be studied without the other. They are merely two points of view, so interrelated as to be inseparable.

The geographical work undertaken by the Finnish society in accordance with this idea has been so perfectly carried out, and represents such an amount of erudition and patient research, that it may well be held up as a model for all works of the same character that may be undertaken in other countries.

Substitutes for Automobile Gasoline*

By Gail Mersereau

During the last few years the development of the automobile and the greatly increased use of gasoline in chemical extraction work, combined with the partial exhaustion of the crude petroleums rich in gasoline, has more than doubled the cost of value of this product. During the last year or two there has been a great demand for some cheaper substitute for use in the automobile engine. The publication in the daily papers of offers of prizes for a solution of the problem has spurred on inventors to work out many ingenious possible solutions.

Denatured alcohol can be used readily. It is clean, not so dangerous as gasoline, and will give three fourths as much mileage as gasoline per gallon (and sometimes better); but it costs much more than gasoline, and it hardly seems probable that the price will decrease greatly in the future.

Kerosene has been used and is being used more and more in heavy trucking. In order to use it in the ordinary motor it is simply necessary to heat the carbureter by means of the exhaust gases. The motor must be started with gasoline or alcohol. There is no difficulty in this, as it is easy to attach a small supplementary tank.

The great drawback to the use of kerosene is its production of polymerized products in the cylinder and the formation of coke and lampblack from these products. This polymerization reaction takes place apparently only in the larger globules of the kerosene which enter the cylinder. The outside layer of oil is partially oxidized, with the formation of high boiling polymers. These then condense on the relatively cool sides of the cylinder. Further explosions in the cylinder oxidize and burn off more of the hydrogen atoms until the material becomes nearly pure carbon.

Alcohol, injected into the cylinders, while still hot, at the end of the day's work, will clean out the greater proportion of these troublesome products. This is too much trouble for the ordinary automobile owner.

To obviate the difficulties above mentioned, namely, the preheating of the carbureter and the production of coke and lampblack, a great many mixtures have been proposed.

All kinds of low boiling point constituents have been added, so that the carbureter need not be preheated, and all kinds of oxygen containing materials have been added to prevent the dehydrogenation and polymerization of the molecule.

Many mixtures of kerosene with acetone, other ketones, alcohol, casing-head gasoline, methyl, and ethyl ether, etc., have been proposed and tried. Many of these mixtures work very well, but the average owner wants a fuel that can be purchased at any point on his travels.

The Southey carbureter[1] or rather "gasifier" seems to work very satisfactorily. In this apparatus the kerosene is sprayed into a chamber, where the spray comes into contact with a small amount of air. A partial combustion takes places, just enough air being admitted to cause sufficient combustion to furnish the heat necessary to gasify the oil. This combustion is started by a spark, but after a minute or two the spark may be cut off. The chamber is so arranged that the large globules of oil from the spray drop to the bottom and are returned to the main tank.

The apparatus works very well in practice. It gives practically no trouble from coking or the formation of evil-smelling products of partial combustion. Kerosene of very much the same composition can be bought all over the world. This seems to solve the problem.

Many methods[2] for the manufacture of gasoline from heavy oils have been proposed and quite a number patented. The principle on which most of these work is the distillation of the heavy oil under pressure. The first lot of these gasolines to reach the New York market a year or so ago, were straw-colored, ill-smelling oils. They had been distilled carelessly and contained considerable proportions of very heavy oils, but during the last few months the quality has been much improved. These gasolines made by high pressure distillation are now being manufactured on a very large scale in this country, but the price is maintained very close to that of the natural petroleum product.

* *Journal* of the Society of Chemical Industry.

[1] Southey, Eng. Pat. 27,612, December 8th, 1911.

[2] For example, Burton, U. S. Pat. 1,049,667, January 7th, 1913; Leffer, Eng. Pat. 2,328, January 29th, 1912.

Peppermint Oil in the Ukraine

The Ukraine is an almost unknown part of the world, but nevertheless a vast, very fertile, and beautiful country; it consists of that portion of Southern Russia known as "Little Russia," together with Ruthenia, which embraces the Austrian provinces of Galicia and Bukovina. A sample of the peppermint oil grown in this locality has been examined and found to have the following characters: Specific gravity, 0.904; optical rotation, —26 degrees; total menthol, 53.8 per cent; esters as menthyl acetate, 6 per cent. It is soluble 1 in 3 volumes of 70 per cent alcohol, becoming slightly opalescent with 10 volumes. The rich black soil of the region and the beautiful climate are most favorable to the cultivation of essential oil-bearing plants. A tobacco grown there, "suitably flavored with peppermint," is universally smoked and enjoyed by the natives.

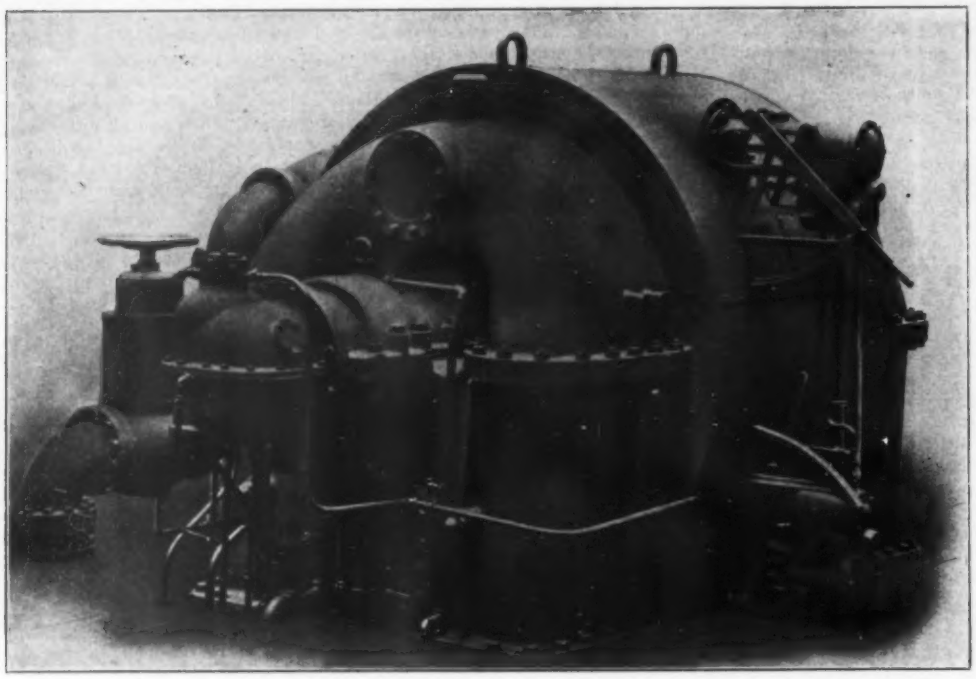


Fig. 1.—Oil relays for opening ahead and astern nozzle valves.

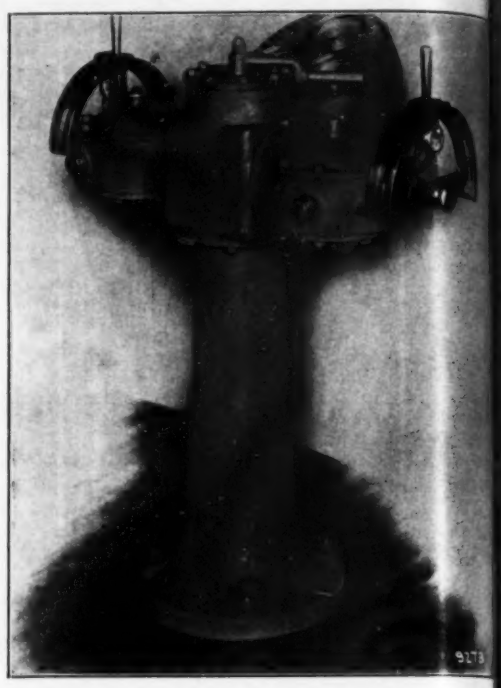


Fig. 2.—Bridge control stand.

The Westinghouse System of Bridge Control*

Apparatus for Controlling a Turbine-Driven Ship from the Bridge

ONE of the most interesting features of the marine turbine drive developed by the Westinghouse Machine Company, which involves the use of high-speed turbines with a floating frame reduction gear interposed between the turbine and the propeller shaft, is the method by which the turbines can be controlled by the navigator on the bridge as well as by the engineer from the starting platform.

After several months' service on the United States collier "Neptune," where this system was first installed, the method of bridge control was found to be thoroughly reliable and of distinct advantage in the operation and maneuvering of a ship in an open seaway and in going alongside a dock. Indicators show the navigator on the bridge just what the turbines are set to do and just what they are doing at every instant, while gages show the air and steam pressures available, so that the action of the propellers is always directly under the control of the officer who is handling the vessel.

The medium used for transmitting to the engine room the movements of the control handle on the bridge is air, while the medium used for the actual operation of the relays moving the steam valve is oil.

DETAILS OF THE CONTROL SYSTEM.

A diagrammatic arrangement of the operating parts of the control system, including the bridge control and steam nozzle valves, is shown in Fig. 3. As will be seen from examining the left-hand part of the illustration, the bridge control lever D' is movable in two quadrants A' and C', with an offset B' parallel to the axis of movement.

When the control lever D' is at B' both the ahead and astern nozzles are closed. The operating handle D' turns a shaft carrying a cam E', which has pressed against it the point of a small valve F''. The valve F'' is hollow and closed at both ends, and has two sets of ports, G' and H', the former always being in communication with the source of high-pressure air supply (furnished by a standard Westinghouse air brake compressor), and the latter having its edge to the extreme left, just line in line with the ports I' in the piston L'. The end of the plunger valve F'' is line in line with the left-hand edge of the ports I'. A small spring K' within the piston L' is provided to maintain a positive contact between the point of the plunger F'' and the cam E', thus fixing the position of the plunger F'' by its point of contact with the cam E'. The movement of the piston L' to the left is resisted by the spring N'. The space J', to the right of the piston L', communicates with space Q' between two diaphragms R' R', and the space to the left of the piston L' communicates with the atmosphere. A communication to the passage within the piston L' to atmosphere is provided by the ports M'.

The diaphragms R' R' control two valves, T'' and U'', the former controlling an opening to atmosphere and the latter an opening to the source of high-pressure air supply. The spaces S' S' are connected by a passage, so that the pressure in them is always equal. The space S' communicates either with the ahead or the astern operating relay in the engine room.

The function of the bridge control valve just described is simply to maintain a predetermined constant pressure in the air relay cylinder, and this is accomplished as follows with the apparatus just described.

OPERATION.

When the lever D' is moved from its central position B' in the ahead quadrant A' the cam E' pushes the valve F'' to the left, thereby bringing the port H' into communication with the port I' in the piston L'. This admits high-pressure air into the space J', and consequently Q'. As the pressure in the space J' increases, it will quickly force the piston L' to the left, until the right-hand edge of the port I' cuts off communication with the port H', or should there be leakage, it will take a position such that the opening through the ports H' and I' would be just large enough to pass sufficient air to make up for the leakage and maintain a constant pressure in the space J'.

Since, normally, the spaces S' S' are at atmospheric pressure, when the pressure between them in the space Q' is increased, the diaphragms are forced outward, closing the valve T'' and opening the valve U', thus admitting high-pressure air into the spaces S' S' until the pressure in the latter is equalized with the pressure in the space Q', thus bringing the diaphragms back to their normal position, permitting the valve U' to seat and thus cut off the supply of high-pressure air. The pressure existing in the space S' is transmitted to the space P to the left of the air relay cylinder in the engine room.

As in the case with the piston L' and the ports I' and H', should there be leakage in the piping system communicating with the space S', the diaphragms R' R' will be distended slightly, thus holding the valve U' open sufficiently to make up the leakage and maintain constant pressure. Conversely, it is evident that if the pressure in the space J' should increase above that predetermined for a given position of the piston F', the piston L' will move to the left, and open communication between the space J' and the inside of the piston L', thus exhausting air from the space J' to atmosphere through the port M'. This condition also arises when operating lever D' is moved toward the off or central position, which permits the movement of the valve F'' to the right. In the latter case the pressure in the space Q' will be decreased and become less than the pressure in the space S' S', causing the diaphragms R' R' to collapse and open the valve T'' to atmosphere until the pressure in the space S' S' is decreased to that in the space Q'.

When the control lever D' is to be moved to the astern position, it is necessary to move it in the direction of its axis of rotation in the slot B'. When this is done an arm W' held between two collars on the cam shaft, moves the small slide valve X' to the right, and brings the pipe Z' to the astern air relay cylinder into communication with space S', and the pipe Z'' into communication with the atmospheric exhaust.

From the above it will be seen that it is impossible for the operator to become confused and accidentally move the control lever in the wrong direction, or try to put it in both the ahead and astern position at the same time, as it is necessary to move the controlling lever sideways before it can be moved from one position to the other.

THE GOVERNOR.

The governor, which controls the speed of rotation of the turbine shaft, is shown on the right of the diagrammatic sketch, Fig. 3. As will be seen, it is of the common fly-ball type, and is driven through the turbine shaft by a worm E and wheel D. The only movable part of the governor is the hollow spindle B, having the ports N and H in it. The movement of the spindle B is restricted by a diaphragm K, to which it is attached. The upper side of the diaphragm is open to atmosphere, and the space below G is filled with oil.

High-pressure oil at about 65 pounds gage per square inch is admitted to the revolving spindle B through the ports A.

When the governor spindle is revolved by the turbine shaft the balls MM are thrown outward by centrifugal force, thus pulling the spindle B downward against the resistance of the diaphragm K, opening communication through the port H in the spindle, and I in the upper spindle bushing, to the space G, the latter communicating through a port L to a pipe connected to the space V of the air cylinder relay.

As the pressure in the space G, below the diaphragm K, increases, it resists the downward thrust of the spindle B, due to the centrifugal action on the governor weights until the upward pressure on the diaphragm exactly balances the downward thrust of the spindle, thus permitting the upward movement of the spindle B by the elasticity of the diaphragm K until the communication through the ports H and I is cut off. Thus it is evident that for any given number of revolutions of the governor spindle there must be a constant fixed pressure of equilibrium in the space G below the diaphragm. Should the pressure in the space G exceed that corresponding to the speed of rotation of the governor at any instant, the spindle B will be forced upward, thus opening communication between the space G and the atmosphere through the ports N in the governor spindle body.

AIR RELAYS.

In the center part of the diagrammatic sketch is shown the air relay cylinder, relay valve and operating cylinder, which control the opening and closing of the nozzles of the turbine according to the speed of rota-

* From *International Marine Engineering.*

tion desired. Referring to this part of the illustration, and starting with the turbine at rest, the piston *Y*, which opens and closes the nozzle valves is at the farthest end of its travel to the right, and all the turbine nozzles are closed. When air from the bridge control valve is admitted to the space *P*, to the left of the air-operating cylinder, the piston *Q* will be forced to the right against the resistance of a small spring, thus carrying the relay plunger *O* with it. The movement of the latter establishes communication between the space *R*, supplied with high-pressure oil, and the space *X*, to the right of the piston *Y*; and the space *W*, to the left of the piston *Y*, is brought into communication with the space *T*, and thereby with the oil return to the reservoir, which is open to atmosphere. Thus the piston *Y* will be forced to the left by the oil pressure and through a rack engaging with the gear cut in the periphery of the nozzle valve, will rotate the latter and open the high-pressure nozzles, thus admitting steam to the turbine. As there is nothing to resist the motion of the piston *Y*, nozzles in excess of those necessary to give the desired speed are opened instantaneously and thus the turbine begins to speed up very rapidly. Now, however, as the turbine gains speed and the governor revolves, the governor spindle *B* is forced down and high-pressure oil is admitted through the ports *H* and *I* and

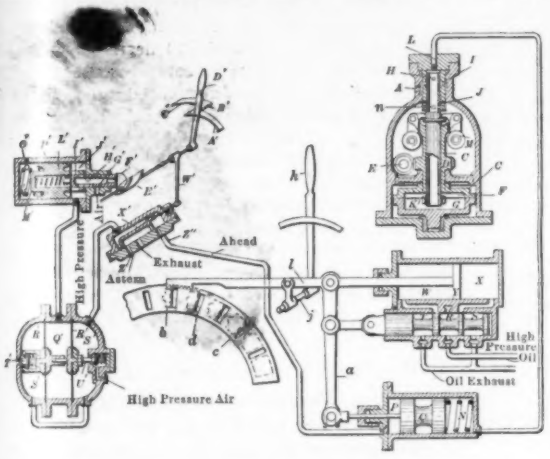


Fig. 3.—Diagrammatic arrangement of bridge control and nozzle valves.

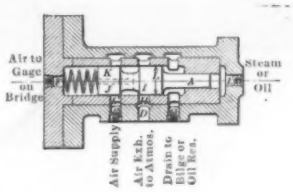


Fig. 4.—Relay valve controlling compressed air in dilating coils.

through the passage *L* to the space *N* to the right of the piston *Q*, thus tending to push it to the left against the air pressure in the space *P*. As the piston *Q* moves to the left it carries the relay plunger *O* with it, and when the oil pressure in the space *N* balances the air pressure in the space *P*, or, in other words, the space *J'* in the bridge control valve, the piston *Q* will take a fixed position, and the piston *Y* will take up a position such that the ports communicating with *W* and *X* are both closed, thus maintaining a constant speed of revolution.

Should the turbine tend to exceed the speed fixed by the air pressure in the space *P*, the piston *Q* would move to the left and bring the space *X* into communication with the space *S*, connected to the oil exhaust, and the space *W* would be brought into communication with the space *R*, supplied with high-pressure oil. This would cause the piston *Y* to move to the right until sufficient nozzles had been shut off to reduce the speed, until the oil pressure in the space *N* was again brought into equilibrium with the air pressure in the space *P*.

"CUT-OUT" VALVE.

The bridge operating stand which supports the bridge control valves is shown in Fig. 2, from which it will be seen that there is a rotary slide valve on top of the stand between the port and starboard control valves. This latter valve is not shown in the diagrammatic sketch previously described, and is not shown in detail because of the difficulty of showing the various ports in it. Its function, however, is to permit operating both turbines, either ahead or astern, by either the port or starboard control valve, or to cut out both the starboard and port control valves. In addition to these functions which this valve performs on the bridge control stand, the similar valve on the control stand in the engine room has a position for cutting out the bridge stand and other operating stands in other portions of the ship. Thus when the control system on the bridge is connected, all control stands excepting that in the engine room are made inactive, while if the stand in the engine room is being used all other stands (including the one on the bridge) are disconnected. This arrangement avoids interference, permits rapid changes from one station to another, but always leaves the engine room stand operative in case of an emergency.

Ordinarily, except when maneuvering, the bridge stand is always connected up so that both turbines are controlled by moving either the port or starboard control levers, which simplifies the operation and permits controlling both turbines if either the port or starboard operating valves should for any reason become temporarily disarranged.

In addition to the standard screw-down valves on the ahead and astern turbines, each turbine is provided with a hand-operating device, by means of which a nozzle valve can be moved by hand, if necessary or desirable.

This is accomplished by the lever *h*, as shown in the diagrammatic sketch, Fig. 3. The lever is pivoted on the shaft *j*, and has a lever engaging with the crosshead on the valve-operating piston rod *l*. The latter lever is fitted with a latch so that it can be quickly connected or disconnected when not in use.

As previously pointed out, there may be a number of operating stations from which the turbines can be controlled when this is desirable, as, for instance, there might be considerable advantage in the case of battleships in having the turbines controlled from the central station as well as from the bridge and starting platform.

GAGES AND INDICATORS.

In order that the officer on the bridge or navigator can see that the turbines are operating as desired, and also to show that the control system is in operating condition, gages are provided which show the steam pressure in the boilers, the air pressure in the control system, the air pressure in the pipe lines *Z' Z''*, as well as the pressure in the oil supply system, and the pressure of the oil under the pistons of the floating frame on the reduction gears.

As it would be frequently necessary to have the piping communicating from the engine room to the bridge in exposed places where it would be liable to freeze, and because of the difficulty of allowing for the hydrostatic head in the pipe between the bridge and the engine room in the case of liquids, the steam and oil pressures are indicated on the bridge by means of compressed air and a small relay valve, such as illustrated in Fig. 4. As the steam pressure or oil pressure to be indicated on the bridge may exceed the air pressure available, the former are reduced in some ratio, such as 2 to 1 or 3 to 1, as required.

In Fig. 4 the orifice *B* is connected to the steam or oil line, and the pressure desired is indicated on the bridge by the air pressure in the pipe connection to *F*, which communicates with the gage on the bridge. The operating element of the relay consists of the plunger *LA*, having *L* and *A* the same diameter, or *A* a smaller diameter than *L*, for relaying oil or steam pressures. The plunger *LA* is fitted in a bushing, having ports *G* and *H*, port *G* communicating with the high-pressure air supply and port *H* communicating with atmosphere. A drain *C* is also provided, which may either drain to the bilge or to the oil reservoir when oil pressure is being relayed.

Normally, when not being used, the small spring pushes the plunger *LA* to the right, and the gage on the bridge is then connected to atmosphere through the ports *K* and *H*. When steam or oil under pressure is admitted at *B*, the plunger *LA* is forced to the left against the resistance of the spring, and the edge *J* of the plunger *LA* moves over the port *G* and admits high-pressure air through the port *K* to the gage on the bridge, the pressure in the space to the left of the plunger *LA* increases, until the pressure times the area of the left-hand portion of the plunger *LA* equals the pressure times the area on the right-hand portion of the plunger *LA;* thus if the diameter of plunger *L* is twice the diameter *A*, the area of the large end of the plunger will be four times that of the small end, and the actual pressure maintained on the left-hand side of the plunger will be one fourth of that maintained on the right-hand side of the plunger, thus 200 pounds gage steam pressure would be indicated on the bridge by 50 pounds of air pressure. The oil pressures are transmitted to the bridge in the same way.

SPEED INDICATORS.

As was pointed out in describing the operation of the controlling system, there is a fixed pressure (for any given number of revolutions per minute of the turbine shaft) in the spaces *Q'* and *S' S'*, as well as under the diaphragm *K* in the governor spindle and the space *N* to the right of the air-operating cylinder. Consequently, instead of graduating the gage recording the air pressure in the space *S'* in pounds, this scale may conveniently be graduated to read revolutions per minute, so that those in charge on the bridge can see every instant exactly the number of revolutions which the propellers are making.

Another novel feature of the new control apparatus used on the U. S. "Neptune" is a set of speed recording instruments. As previously mentioned, for any given turbine speed there will be a definite oil pressure under the diaphragm *K* of the governor, and consequently this pressure can be used to indicate the speed of the turbine and propeller.

Pressure gages of the recording type may be used, showing the speed, direction of rotation, and period of operation of each turbine under any given conditions. These records furnish an accurate log which is indisputable in case of a controversy regarding the speed or manner in which the turbines were operated. These cards can be graduated to read revolutions or knots, as desired.

Hardness of Metals

In the *Int. Zeitschrift Metallographie* J. H. Andrews summarizes the views of Edwards and Grenet on this subject and points out that in several respects the ideas are opposed. Brinell hardness tests on quenched and slowly cooled Cu-Al and Cu-Sn alloys showed that quenching actually softens some of the alloys. This proves that Edwards's theory stating that "any alloy retained as a homogeneous solution which would otherwise consist of two constituents is thereby rendered much harder," does not hold good in all cases. Consideration is then given to the particular case of iron-carbon alloys which differ from the Cu-Al alloys under discussion in that the phases separating at 700 deg. Cent. are a pure metal (ferrite) and a pure metallic compound (cementite), while in the Cu-Al alloys the phases separating at 570 deg. Cent. are two homogeneous solid solutions. Further, one of the constituents separating from the iron-carbon alloys at the inversion point, undergoes an allotropic change at the same temperature. In the light of Benedicks's theory austenite consists of a solid solution of carbon or carbide of iron in γ-iron, while martensite is a solid solution of carbon or cementite in a solution of α- and γ-irons. The author believes martensite to be made up of free cementite embedded in a matrix of undecomposed austenite and α-iron the latter accounting for the magnetic properties of hardened steel, while the hardness is due to the combined effect of the solid solution and the carbide. Alloys of iron and carbon do not appear to fall into line with the non-ferrous alloys in any generalization on the property of hardness.

New Uses for Infusorial Earth

Infusorial earth is being mined more actively in California and Nevada, which produced nearly 90 per cent of the 6,582 tons output last year in the United States. The value, according to a recent daily consular and trade report, averages $10.50 per ton. Heretofore diatomaceous or infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but the United States Geological Survey finds that of late its uses have been considerably extended. Because of its porous nature it has been used in the manufacture of dynamite as a holder of nitroglycerine, but so far as known not in the United States. Its porosity also renders it a non-conductor of heat, and this quality in connection with its lightness has extended its use as an insulating packing material for safes, steam pipes, and boilers, and as a fireproof building material. In this country a new use of the material is reported in the manufacture of records for talking machines. For this purpose it is boiled with shellac, and the resulting product has the necessary hardness to give good results. In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manures; in the manufacture of water glass, of various cements, of glazing for tiles, of artificial stone, of ultramarine and various pigments; of aniline and alizarine colors; of paper, sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, scouring powders, papier-maché, and many other articles. There is a large and steadily growing demand for it.—*The Chemical News.*

Wireless Equipment on Aircraft*

By Marcus D. Manton

THE WORKING PRINCIPLE.

PERHAPS a few words relating to how radiotelegraphy works would not be out of place. Wireless telegraphy signals are transmitted from one station to other stations by means of a series of waves which are set up in a wire or system of wires (which is insulated from all objects in contact with the ground) by means of electric oscillations. The system of wires employed is known as an aerial or as antennæ.

These electric oscillations in the aerial create a disturbance in the surrounding ether, and the message goes forth by means of electro-magnetic waves in the ether, in a somewhat similar way to the ripples created by dropping a stone into a pool of water. Ether may be defined as a rarefied element, all-pervading and intangible; it is also by means of these ether waves that light reaches the earth.

The energy creating these waves is simply an electric current which surges back and forward from end to end of the aerial, this change of direction taking place many thousands of times per second, and is what is commonly known as an alternating current. Whenever an operator presses a key, an oscillating current is supplied to the aerial; this sets up waves which go out into the ether and travel along in all directions until they come into contact with other aerials (the waves do not stop when they reach aerials, but pass along until they gradually damp themselves out), and in these aerials set up corresponding oscillations, which are made audible to operators at these stations by means of a detector and telephone receivers (there are many types of detectors in use, but these are too numerous to describe here)—see Fig. 1.

The current which produces the necessary oscillations in the aerial is generated by an alternator driven by an engine or motor of some kind or by means of an electric battery and induction coil (trembler, spark coil somewhat similar to the coils used for the ignition on automobiles).

Up to the present, and in fact even now, great difficulty is experienced in receiving wireless telegraph messages in an aeroplane; the waves reach the receiving aerial thereon, but the noise of the engine is so terrific that it makes the faint signals in the telephone receivers inaudible.

True, there are other ways of recording these signals—by means of Morse inkers, syphon recorders, etc., but these instruments require more than the minute currents which are produced by the ether waves, coming in contact with the receiving aerial, to operate them, and it is therefore necessary to employ a relay, which is an instrument which will automatically switch on an electric battery and supply the current necessary for working the Morse writer or whatever instrument is employed. Again, a relay is practically useless if it is subjected to any vibration, so until the aeroplane is produced that is silent or vibrationless, the reception of wireless messages on aeroplanes will remain a very difficult problem.

In the case of the dirigible the matter is simplified, since it can be fitted up with a silence cabinet wherein the operator could work undisturbed by the noise of the motors. And in any case the motors can be far more easily silenced than on aeroplanes.

TRANSMITTING WIRELESS MESSAGES FROM AIRCRAFT.

Though not without difficulties, transmitting wireless messages from aircraft is a good deal simpler than receiving messages, since the noise and other disturbing factors in this case are of no consequence.

The apparatus required to make this wireless transmission possible is as follows:

An alternator and transformer, the alternator being driven by the engine used for propelling the machine, or by means of an auxiliary engine or motor of some description, or in place of this alternator and transformer an induction coil may be used, the electric current being supplied to it from a battery of accumulators.

One of the two above-mentioned devices is necessary to supply the transmitting aerial or antennæ with energy, and in order to produce the necessary oscillations in the aerial a spark gap must also be provided (Fig. 2). A spark gap in its most simple form consists of two adjustable metallic knobs supported by pillars of a highly insulating substance; these pillars in turn being fixed to a base made of some non-conducting material. The spark knobs are mounted on brass rods and are arranged so that by pushing the rods inward or pulling them outward the distance between the spark knobs can be varied at will, until the most efficient distance between the knobs is found. This distance is known as the gap.

A key is also necessary to enable the operator to make and break the electric circuit at will, in order to produce dots and dashes for transmitting a message in the Morse or other prearranged code.

A transmitting set in its simplest form is shown in Fig. 3.

It will be noticed in the diagram that a ground connection is also made, in addition to one to the aerial or antennæ; and as it is impracticable to trail a wire from an aircraft to the ground, some other system must be adopted. This difficulty is surmounted by using a counter poise which is a system of aerials similar to those devised by Lodge. It consists, in fact, of two distinct aerials, apart from one another and each highly insulated (Fig. 4). By this means a ground connection is not essential.

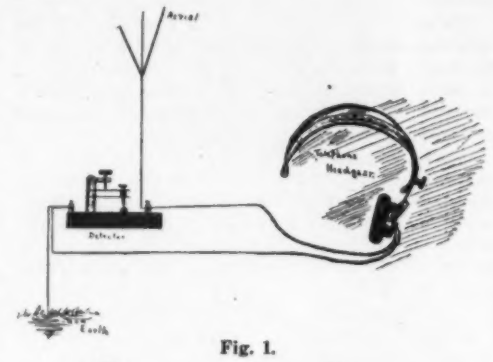


Fig. 1.

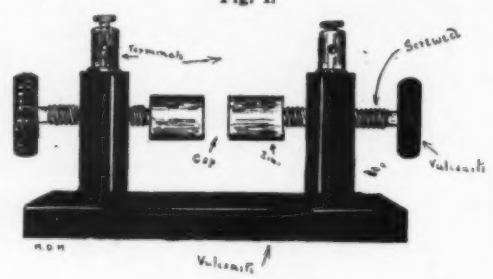


Fig. 2.

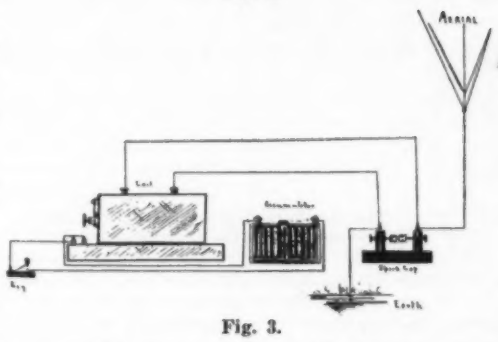


Fig. 3.

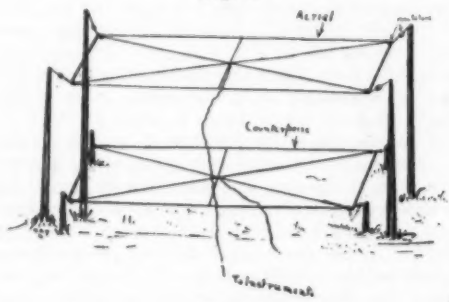


Fig. 4.

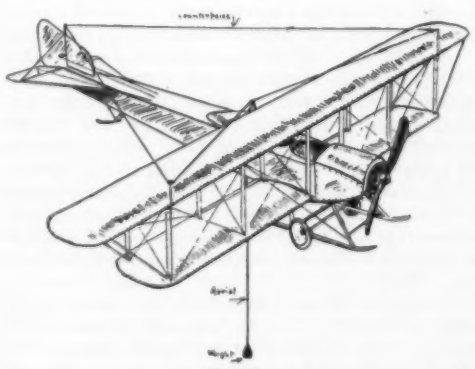


Fig. 5.

AERIALS ON AIRCRAFT.

These usually consist of a single copper cable about 60 to 100 yards long, one end of which is connected to the instruments; to the free end a weight is attached and then lowered over the side of the machine so that it hangs vertically below the machine when in flight. A winch is provided so that the aerial may be quickly wound up or down.

In the event of the machine having to make a forced landing and giving no time to wind up the aerial, the wire cable is severed by means of an aerial cutter which is fitted to the side of the winch, and the wire falls clear of the machine so that the aeroplane lands in the ordinary way without any danger of the aerial catching in trees or being tangled up by the propeller.

The counterpoise used in place of the ground connection consists of a system of wires running from the planes to the tail of an aeroplane or from end to end of the nacelle of a dirigible. Fig. 5 shows how a counterpoise and aerial are fitted to an aeroplane.

The object of this article is to try and explain in a non-technical manner the working principle of wireless telegraphy as applied to aircraft, and to show what a large field is open for inventors and experimenters.

* Reproduced from *Aircraft*.

Turpidity of the Upper Atmosphere in 1912

SINCE the celebrated eruption of Krakatoa there has been no hesitation to attribute the darkening of the sky which occurs from time to time to volcanic eruptions, which sometimes becomes sufficiently serious to interfere with astronomical observations. The volcanic origin of these clouds of dust, which always float very high, has been verified so often that the observed turbidity of the upper atmosphere during the summer and autumn of 1912 has naturally been attributed to the violent eruption of Mount Katmai, in Alaska.

This view has been called in question by Dr. Barkow of the Filcher Antarctic Expedition, who observed a similar turbidity in latitude 70 degrees South in the middle of June, 1912, and for several months thereafter. He observed cirrus clouds at unusual altitudes and was able to read several hours daily by the light of the sky, although the sun was below the horizon, even at noon. In short, everything indicated the presence of reflecting particles at exceptional altitudes.

As it seems impossible that the dust of Katmai could have reached the Antarctic so soon after the eruption, Dr. Barkow concludes that the phenomena observed by him were caused by dust of cosmic origin, although this may have been reinforced, in the northern hemisphere, by volcanic dust from Mount Katmai.—From *Cosmos*.

Wireless Telegraph Station at the German Observatory at Spitzbergen

AT this station a ½-kilowatt Telefunken apparatus is established, with a ship's antenna 20 meters high, by which communication can be had with the station at Green Harbor and thence to Europe. For fixing time, Green Harbor sent time signals, at first without confirmation from the observatory, by means of a chronometer checked by time signals from the Eiffel Tower. To receive time signals at the observatory the author erected an earth antenna 40 meters long in the direction of the azimuth of the sending station, and laid on the snow with which the ground was covered. With this primitive arrangement Green Harbor (135 kilometers) was continually heard, and Ingö (1,000 kilometers) occasionally. Later an earth antenna 230 meters long, and carried on insulating posts 1 meter high, was erected. Signals from Ingö were then regularly received.

The author says that it is generally well known that the strength of signals in the Arctic is subject to extraordinary variations, although the energy from the sending station remains constant. The variations seem to follow no law, but the sudden increase and decrease in the received energy is due to some as yet unexplained influence. Examples of these remarkable variations are given. The author experimented in order to receive the Paris and Norddeich time signals, and although these can be received quite well at Green Harbor with 4 ohms in parallel to 1,000 ohms, no results were obtained with the type of antenna previously described. Various types of antennæ were tried, but instead of improvement, signals were actually weakened. Satisfactory results were eventually obtained by two earth antennæ, whose free ends were connected to horizontal triangles. The clear tone of the Telefunken station at Norddeich is stated to be more suitable for reception with signals of varying strength than the growling note of Paris. It was rarely found possible to receive the complete series of time signals owing to the variations before alluded to.

An aeronautical apparatus was available at the observatory, balloon antennæ were experimented with, but the results were not strikingly better. By means of the direct time-signal reception from Paris it was found possible to determine very exactly the longitude at Ebeltofthaven.

The author emphasizes the usefulness of time signals to surveying expeditions, as very primitive and portable receiving apparatus can be employed.

Later experiments were made to see if transmission to Green Harbor was possible using the earth antennæ. No success was obtained, though a small receiving station 7 kilometers away and in a southwesterly direction from the observatory received signals. A balloon

antenna was tried using the earth antenna as counter capacity, and communication with Green Harbor was effected, the antenna having a capacity of 500 centimeters and the antenna current being 5 amperes. A small ship-type antenna was finally erected, and the original type of earth antenna used as a counter capacity, satisfactory earth in the Arctic region not being easily obtained. With this antenna satisfactory communication was secured.

The paper is accompanied by a plan and elevation of the complete antenna system.

A Water Rheostat

In a communication to *Power*, P. M. Anderson tells how to build a water rheostat that is very simple in construction and can be put together quickly with ordinary material that can be picked up anywhere. The author claims that it is quite satisfactory, and gives the following description.

The drawing, Fig. 1, shows a 2,200-volt, single-phase

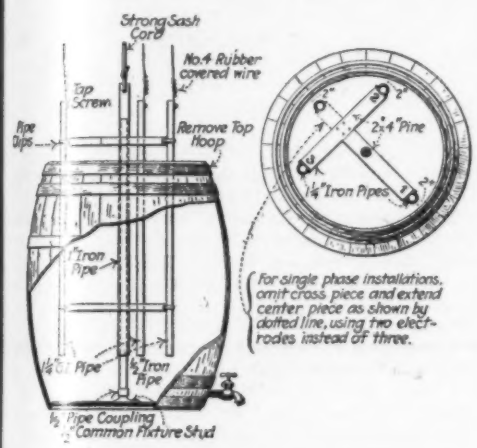


Fig. 1.—Details of construction of rheostat.

or three-phase water rheostat constructed from material which is always available around a power plant. Two frames are constructed in the form of a T, to which 1½-inch pipes are secured at the three ends, as shown. This triangle of pipes forms the electrodes, to which wires of any convenient size are attached by soldering or by means of screws. A 1-inch pipe is placed in the center of the triangle as a support and guide for the electrodes, and a ½-inch pipe is secured in the center of the bottom of any large barrel. This latter pipe fits inside of the first, so as to prevent the electrodes from swinging to the edges of the barrel. It is well to remove the top hoop, as it prevents the possibility of charring the ends of the staves. A hose bibb can be inserted near the bottom of the barrel for attaching a ¾-inch hose, or the hose can be dropped into the top of the barrel. The rheostat can be supported on blocks of wood or rest directly on the ground. Water can be allowed to overflow the top edges of the barrel or may be carried away through a pipe attached near the top.

When the barrel is filled with water the electrodes can be easily adjusted to a level position so as to equal-

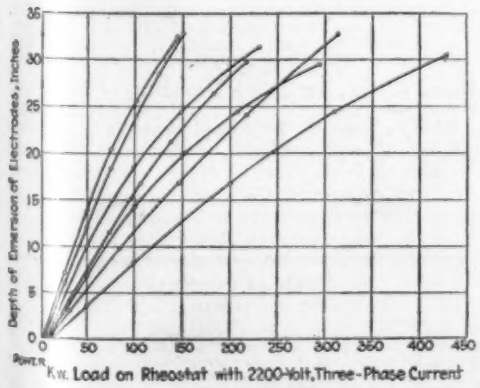


Fig. 2.—Capacity emersion curves.

ize the load on each phase. Any desired load within the capacity of the rheostat can be obtained by adjusting the depth of emersion. The capacity of such a rheostat depends on the quality and quantity of water available for cooling purposes. The chart in Fig. 2 shows a few capacity-emersion curves for different qualities and pressures of water. The form of the load curve depends upon the quantity, hence the pressure of cooling water and the angle or slope of the curve depends on the quality of the cooling water. The lower curve is the result of using slightly brackish cooling water.

The writer has used this type of rheostat extensively on 2,200 volts in various sections of the country. A rheostat constructed with a 56-gallon oil barrel and electrodes in a triangle 13 inches on centers will have a capacity of from 50 to 400 kilowatts. Mere contact of the electrodes with the water will produce a load of from 3 to 15 kilowatts. The capacity can be increased by reducing the size of the triangle or increasing the size of the electrodes, but in no case should the electrodes be less than eight inches on centers. With a steady flow of cooling water constant load can be maintained.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

To the Editor of the Scientific American Supplement:

In Notes and Queries, No. 13007, W. C. P. gives "graphical solutions" for the formation of magic squares of the third and fourth orders. Working along this line I have constructed a number of designs for squares of these and higher orders.

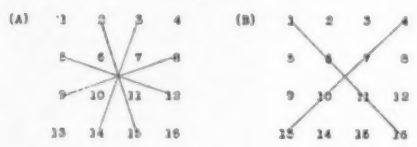
Considering, first, squares of an even order: When we set down the numbers 1 to 16 in the form of a square, thus:

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

we observe that the sum of each diagonal is the same (34), which is to be the sum of the magic square; and, further, that the sum of each pair of cells in a diagonal holding the same relative position in regard to the center is the same, viz., 1 and 16, 6 and 11, 4 and 13, 7 and 10. Now there are eight possible permutations of the cells in each diagonal that preserve this relationship, viz:

(A)	1	6	11	16	and	4	7	10	13
(B)	16	11	6	1	and	13	10	7	4
(C)	1	11	6	16	and	4	10	7	13
(D)	16	6	11	1	and	13	7	10	4
(E)	6	1	16	11	and	7	4	13	10
(F)	11	16	1	6	and	10	13	4	7
(G)	6	16	1	11	and	7	13	4	10
(H)	11	1	16	6	and	10	4	13	7

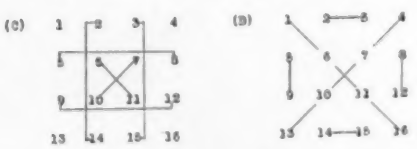
By using these eight arrangements of the diagonals as a starting point it is possible to construct eight different designs by which magic squares of the fourth order may be formed. They are as follows:



Sum, 34.

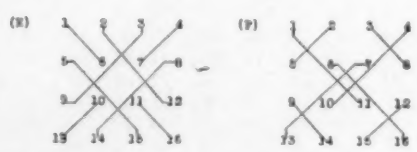
Magic Square			
1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

Magic Square			
16	2	3	13
5	11	10	8
9	7	6	12
4	14	15	1



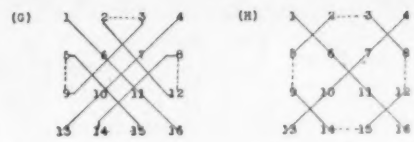
Magic Square			
1	14	15	4
8	11	10	5
12	7	6	9
13	2	3	16

Magic Square			
16	3	2	13
9	6	7	12
5	10	11	8
4	15	14	1



Magic Square			
6	12	9	7
15	1	4	14
3	13	16	2
10	8	5	11

Magic Square			
11	5	8	10
2	16	13	3
14	4	1	15
7	9	12	6



Magic Square			
6	9	12	7
3	16	13	2
15	4	1	14
10	5	8	11

Magic Square			
11	8	5	10
14	1	4	15
2	13	16	3
7	12	9	6

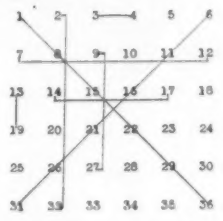
Of course, this by no means exhausts the combinations of 16 cells that form magic squares. Again referring to Fig. 1 we observe that the sum of the first and fourth horizontal rows is 68, which is equal to the sum of the second and third rows. As we rearranged the cells in the diagonals, so we may rearrange the rows of cells, going through the eight permutations that preserve the original relationship, and apply each design to each rearrangement. Likewise, we may turn the original square through a quarter-circle, obtaining the square:

4	8	12	16
3	7	11	15
2	6	10	14
1	5	9	13

to which the various designs may be applied.

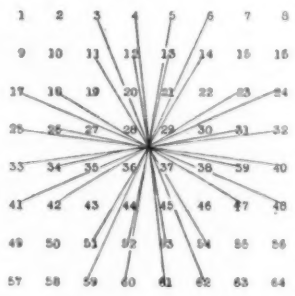
In general it is true that the sum of any pair of cells in a diagonal holding the same relative positions in regard to the center is the same, and a factor of the sum of the magic square.

As we pass to squares of higher orders it becomes obvious that the number of permissible permutations of the cells in the diagonals increases rapidly, so that it would seem that there were many possible designs for magic squares of the higher orders. The following designs illustrate several types of designs.



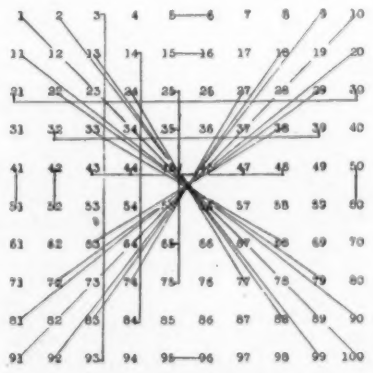
Sixth order. Sum, 111.

Magic Square					
36	32	4	3	5	31
12	29	27	10	26	7
19	17	22	21	14	18
13	20	16	15	23	24
25	11	9	28	8	30
6	2	33	34	35	1



Eighth order. Sum, 260.

Magic Square.							
1	2	62	61	60	59	7	8
9	10	54	53	52	51	15	16
48	47	19	20	21	22	42	41
40	39	27	28	29	30	34	33
32	31	35	36	37	38	26	25
24	23	43	44	45	46	18	17
49	50	14	13	12	11	55	56
57	58	6	5	4	3	63	64



Tenth order. Sum, 505.

Magic Square

100	99	93	4	6	5	7	8	92	91
90	12	88	84	16	15	17	83	19	81
30	70	23	77	75	26	74	28	72	21
31	39	68	67	65	36	64	63	32	40
51	52	48	47	56	55	44	43	49	60
41	42	53	54	46	45	57	58	59	50
61	62	38	37	35	66	34	33	69	70
71	29	73	27	25	76	24	78	22	80
20	82	18	14	85	86	87	13	89	11
10	9	3	94	96	95	97	98	2	1

In the sixth order design, 3 and 33 might have been interchanged instead of 2 and 32; then 13 and 18, 2 and 5, 7 and 25, 9 and 10, and 14 and 20 would interchange instead of those given. The changes in the diagonals would remain the same. The resulting magic square would be:

36	5	33	4	2	31
25	29	10	9	26	12
18	20	22	21	17	13
19	14	16	15	23	24
7	11	27	28	8	30
6	32	3	34	35	1

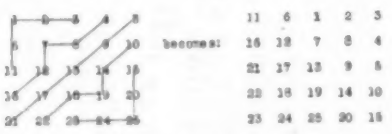
Thus the type designs may sometimes be varied.

It will be found in the foregoing squares that the difference between the sum of any row, horizontal or vertical, and the sum of the magic square is an even number.

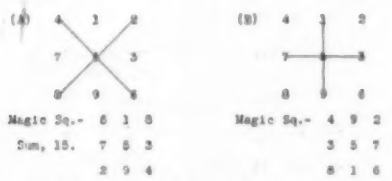
Passing to squares of odd orders: By setting down the nine digits in the form of a square thus:

1	2	3
4	5	6
7	8	9

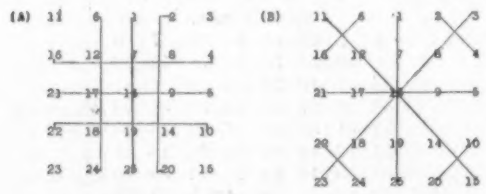
we observe that the sum of each central row of cells is equal to the sum of the diagonal. Further, the difference between the sum of the first horizontal row and the sum of the magic square is an odd number (15 − 6 = 9). It is, therefore, impossible to construct a symmetrical design with the digits in this order. In the case of a square of the fifth order the difference between the sum of the first row and the sum of the magic square is an even number (65 − 15 = 50), but the difference between the sum of the second row and the sum of the magic square is an odd number (65 − 40 = 25). In order to obtain an odd square that fulfills the conditions under which a symmetrical design may be constructed, turn the square so that the diagonals become the centrals and vice versa. Thus,



There are two possible designs for squares of the third order:



In a square of the fifth order there are eight permissible permutations of the cells of the diagonals, as in the case of the fourth order. These serve as the basis of eight designs:



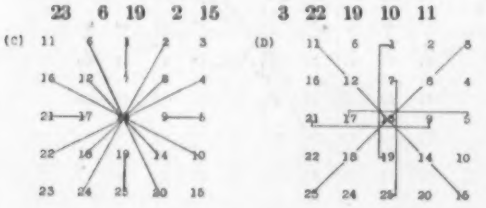
Sum, 65.

Magic Square (A)

11	24	7	20	3
4	12	25	8	16
17	5	13	21	9
10	18	1	14	22
23	6	19	2	15

Magic Square (B)

15	16	7	4	23
6	14	25	18	2
17	5	13	21	9
24	8	1	12	20
3	22	19	10	11

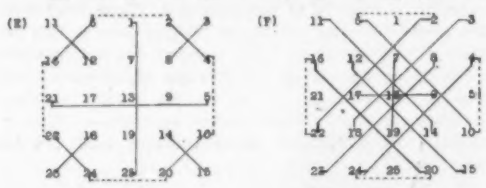


Magic Square (C)

11	20	7	24	3
10	14	1	18	22
17	21	13	5	9
4	8	25	12	16
23	2	19	6	15

Magic Square (D)

15	6	19	2	23
16	12	25	8	4
9	5	13	21	17
22	18	1	14	10
3	24	7	20	11

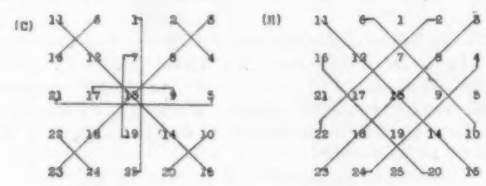


Magic Square (E)

12	4	25	16	8
24	11	7	3	20
5	17	13	9	21
6	23	19	15	2
18	10	1	22	14

Magic Square (F)

14	22	1	10	18
2	15	19	23	6
21	9	13	17	5
20	3	7	11	24
8	16	25	4	12



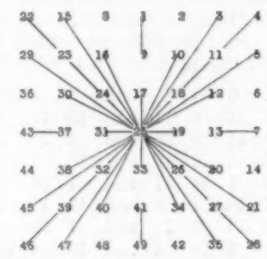
Magic Square (G)

12	16	25	4	8
6	15	19	23	2
5	9	13	17	21
24	3	7	11	20
18	22	1	10	14

Magic Square (H)

14	10	1	22	18
20	11	7	3	24
21	17	13	9	5
2	23	19	15	6
8	4	25	16	12

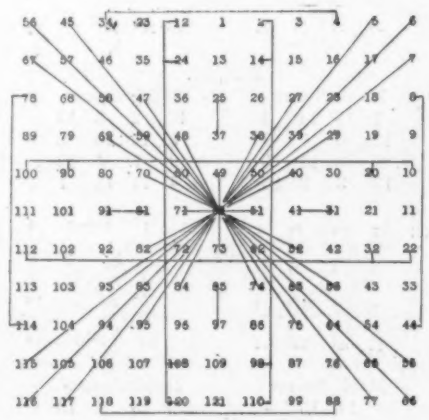
In the following designs, the squares have been first rearranged according to the scheme already given.



Seventh order. Sum, 175.

Magic Square

28	35	8	9	2	47	46
21	23	34	1	40	11	45
36	20	24	33	18	38	6
37	43	19	25	31	7	13
44	12	32	17	26	30	14
5	39	10	49	16	27	29
4	3	48	41	42	15	22

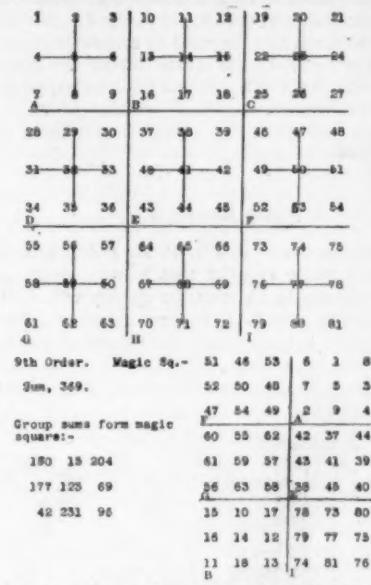


Eleventh order. Sum, 671.

Magic Square

66	77	4	23	120	1	116	3	34	117	116
55	65	46	35	108	13	98	15	16	105	115
114	68	64	75	36	37	26	95	94	18	44
89	79	53	63	74	25	84	83	93	19	9
10	20	80	52	62	73	72	82	30	90	100
111	101	81	91	51	61	71	31	41	21	11
22	32	92	40	50	49	60	70	42	102	112
113	103	29	39	38	97	48	59	69	43	33
78	104	28	27	96	85	86	47	58	54	8
7	17	106	107	24	109	14	87	76	57	67
6	5	88	119	12	121	2	99	118	45	56

Orders whose factors are numbers for which designs are known are easily constructed; e. g., a square of 81 cells may be arranged as nine groups of nine cells each. Each group is treated as a third order square, and the groups are themselves treated as a third order square.



In the same way a magic square of the twelfth order may be made by forming nine groups of 25 cells each or 25 groups of nine cells each, and so on. The numbers may be written consecutively, instead of in groups as in the diagram, and then divided off into groups. Also the various types of designs for an order may be used indiscriminately.

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361 Broadway,
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SCIENTIFIC AMERICAN SUPPLEMENT
Founded 1876
NEW YORK, SATURDAY, OCTOBER 3, 1914
Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter
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Scientific American (established 1845) . . . . " 3.00
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The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
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